UNITED STATES

COAST AND GEODETIC [illegible]

T. C. MEN[illegible]

[illegible]

DETERMINATIONS [illegible]

FOR THE [illegible]

UNITED STATES

COAST AND GEODETIC SURVEY

T. C. MENDENHALL

SUPERINTENDENT

GEODESY

DETERMINATIONS OF LATITUDE AND GRAVITY

FOR THE HAWAIIAN GOVERNMENT

By E. D. PRESTON, Assistant

APPENDIX No. 14—REPORT FOR 1888

WASHINGTON
GOVERNMENT PRINTING OFFICE
1890

Anamoehaole.
(9,300 feet.)

Pakaoao.
(10,000 feet.)

Crater of Haleakala—Looking towards Kaupo Gap from Vicinity of Pakaoao.

APPENDIX No. 14.—1888.

DETERMINATIONS OF LATITUDE AND GRAVITY FOR THE HAWAIIAN GOVERNMENT.

By E. D. PRESTON, Assistant.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 8, 1889.

DEAR SIR: I have the honor to transmit you to-day my report on the observations and computations made for the Hawaiian Government.

This report is somewhat fuller in illustration and in detail than would have been necessary, had it been made on work done in this country and written only to appear in the annual Coast and Geodetic Survey Report, several sketches and one or two forms of computation being introduced which have already appeared in our Reports, but which it was thought best to give, inasmuch as many persons who will read the report have not access to the Coast Survey publications.

In a letter recently received from Surveyor-General Alexander, he says they look with great interest for the appearance of the report.

The results are, moreover, of general scientific interest. Professor Dana says (American Journal of Science, February, 1889, page 87): "They afford unexpected evidence on these doubtful points" (density of volcanic mountains).

The addition of relative forces of gravity at eight new stations to the data already existing furnishes considerable matter bearing on the determination of the earth's figure, especially as these stations have a range of about 50 degrees in latitude and 10,000 feet in elevation.

The lengths of the Peirce pendulums are published here for the first time.

In view of the above statements I beg leave to ask you whether this report could not be made special and published immediately. The Hawaiian Survey could then have their copies without delay.

I remain, very respectfully, your obedient servant,

E. D. PRESTON,
Assistant.

To the SUPERINTENDENT OF THE
COAST AND GEODETIC SURVEY,
Washington, D. C.

NOTE ON HAWAIIAN PRONUNCIATION.

As some native words necessarily appear in this report, in order to aid those readers who may not be familiar with the Polynesian languages the following remarks are made: Two invariable rules lie at the foundation of Hawaiian pronunciation; every word must end with a vowel

and no two consonants are pronounced without an intervening vowel. When the missionaries reduced the language to writing, about 1820, they adopted the Latin pronunciation. Each character represents but one sound, so that the language is entirely phonographic. The vowels are then to have the sounds given them in the Romance languages (except u, which has the sound given it in Spanish and Italian, and not that of the French), and the consonants are in general close approximations to the corresponding ones in those languages. A few exceptions exist, arising from the inability of the early Hawaiians to distinguish between t and k and l and r. The word for star is pronounced indifferently "hoku" or "hotu," and the French travelers, in 1819, wrote Onorourou for Honolulu. As the missionaries found only two words in the language having the sound of d, viz, "hido" and "lido," this sound in those words is replaced by the sound of l in the Hawaiian of to-day. Although two consonants may not appear together, any number of vowels are allowable, as, for example, in the words Pakaoao and Hooiaioia, and in the sentence "E ae au ia oe." The accent is generally on the penult, as in Honolulu, Kohala, Kahuku, etc.

REPORT.

The latitude and gravity observations made for the Hawaiian Government during the year 1887, may be said to have had their origin in the determination of a latitude on the island of Maui in 1883. Two members of the United States Solar Eclipse Expedition stopping here on their way home, in order to determine the force of gravity at De Freycinet's station of 1819, furnished the Government Survey with a value of the latitude of Lahaina which differed 15″ from that derived from Honolulu, and based on the English observations of 1874. In order to test the astronomical observations at the two extremities of the triangulation, Prof. W. D. Alexander, the Surveyor-General of the islands, at once conceived the project of having a number of latitudes of precision determined, which should not only include Maui, but all the larger islands. Owing, however, to lack of appropriations, this plan could not be immediately realized, and it was not until 1886 that a formal request was made by the Hawaiian Government for the loan of the necessary instruments, and the detail of an observer to execute the work.

The following letter states the conditions under which the work was undertaken:

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., December 10, 1886.

SIR: In pursuance of the request of the Hawaiian Government, communicated through the Hon. H. A. P. Carter, Hawaiian minister, and of your own letter of this date, and under authority of the Treasury Department contained in letter of December 9, you are hereby granted a leave of absence, without pay, from December 15, 1886, for six months or such portion thereof as may be necessary, for the purpose of making certain astronomical and geodetic observations, and probably some gravity experiments at the expense and under the direction of the Hawaiian Government.

The necessary instruments and accessories for this work will be supplied by the Coast and Geodetic Survey and will be held at the risk of the Hawaiian Government. It is understood that copies of all the observations made will be furnished for the use of this office.

Yours, respectfully,

F. M. THORN,
Superintendent.

E. D. PRESTON,
Subassistant Coast and Geodetic Survey, Washington, D. C.

The scheme proposed by Professor Alexander contemplated the occupation of fourteen latitude stations, of which three were on Kauai, three on Oahu, four on Maui, and four on Hawaii. But as the object of the observations was the determination of the deflections of the plumb-line, and as this depends on the density of the mountains, it was thought advisable to supplement the latitude work by some measurements of the force of gravity. Therefore the original plan was extended so as to include pendulum observations on the summit of Haleakala, Maui, at a station near the sea-level of the same island and at Honolulu. This last station was also occupied in 1883, which gives a connection between De Freycinet's station and all the stations of 1887.

In view of the general scientific interest in the question of plumb-line deflections, the Hawaiian Government was led to ask, through the Honorable H. A. P. Carter, Envoy Extraordinary and Minister Plenipotentiary at Washington, that the observations might be reduced and discussed according to modern methods by the Coast and Geodetic Survey. The matter was taken up immediately, and the computations begun on January 1, 1888. In addition to these reductions, the length and position of the center of mass for each pendulum has been determined, a bulletin* has been published giving some preliminary results of the work, and some original investigations made for the sake of shortening the methods of reduction.

To this report are also appended the results of pendulum observations at three continental stations occupied in 1887, and three island stations occupied in 1883. The former being all in the same journey, and the latter being occupied by one of the same observers and using the same instrument, and the two journeys having two stations in common, they naturally fall in the same series and should appear together.

Professor Alexander was present at Puuloa and on the summit of Haleakala. Messrs. F. S. Dodge and W. A. Wall, of the Government Survey, took part in the pendulum observations at the three island stations, and Mr. Wall was with the party during the entire season and recorded the latitudes. Mr. Dodge recorded part of the observations at Kahuku, and Mr. J. S. Emerson part of those at Ka Lae. All the time and latitude, and one-half the pendulum observations, were made by myself. At San Francisco I was assisted by Mr. C. B. Hill; at the Lick Observatory by Mr. J. E. Keeler, and at Washington by Mr. J. B. Baylor. My thanks are due to all these gentlemen, as well as to Professor Davidson, Prof. E. S. Holden, and to the trustees of the Lick Observatory for interest in the work and for facilities given for its successful execution.

In the work of 1883 Prof. S. J. Brown, U. S. Navy, one of the members of the eclipse expedition, assisted in the observations at Caroline Island, at Lahaina, and at Honolulu. Mr. C. B. Hill took Professor Brown's place at San Francisco.

INSTRUMENTS.

The following was the instrumental outfit:

Davidson meridian telescope, Coast and Geodetic Survey No. 1; sidereal break-circuit chronometer, Frod. 3479; sidereal break circuit chronometer, Hutton 221, yard pendulum, Peirce No. 3; metre pendulum, Peirce No. 4; pendulum head, Peirce No. 0; sidereal chronometer watch, Jurgensen 7932; mercurial barometer, Green 2016; amplitude scale; aneroid barometer (Pitkin); chronograph, Fauth No. 5; reading telescope; condensing lens (5-inch diameter); Baudin thermometers, 9242, 9243, 9248, 9252; switch board; brass temperature tube; gravity battery (3 cells); extra levels (2); electrical connections, insulated wire, observing key, lamps, mirrors, and other necessary accessories.

Most of this list was supplied by the San Francisco sub-office. The pendulums, thermometers, and watch were furnished from Washington.

The meridian telescope has an aperture of 2½ inches; focal length, 31½ inches; magnifying power 60 was used; one revolution of eye-piece micrometer=$64''.35$; one division of latitude level=$0''.92$; one division of striding level=$1''.05$, and one division of azimuth micrometer=$1''.66$.

The yard and metre pendulums are both of the invariable reversible type; the distances of the center of mass from the two knives are as three to one. The times of oscillation in the two positions differ by $0^s.00003$ for pendulum No. 4, and by $0^s.0002$ for pendulum No. 3.

The Frodsham chronometer breaks the circuit at the first second and at every even one. Hutton breaks the first second, every even one, and the half second immediately preceding the even one.

One division of the amplitude scale is equal to 0.050 inch. The distances from the point of support to the end of the pendulums are, for pendulum No. 3, 46.44 inches; pendulum No. 4, 1.291 metres. Hence in the former case one division is equal to .00108 R, and in the latter to .00098 R.

On December 15, 1886, a leave of absence without pay for six months was granted me. Leaving Washington on this date I arrived in Honolulu on the 12th of January, having stopped in San Francisco long enough to test and pack the instruments. Nine days later the first observations were made at Puuloa. The Government placed at our disposition the steam-tug *Pélé*, which transported the party and instruments to Pearl Harbor. Arriving at 4.30 p. m., January 21, observa-

* No. 11.

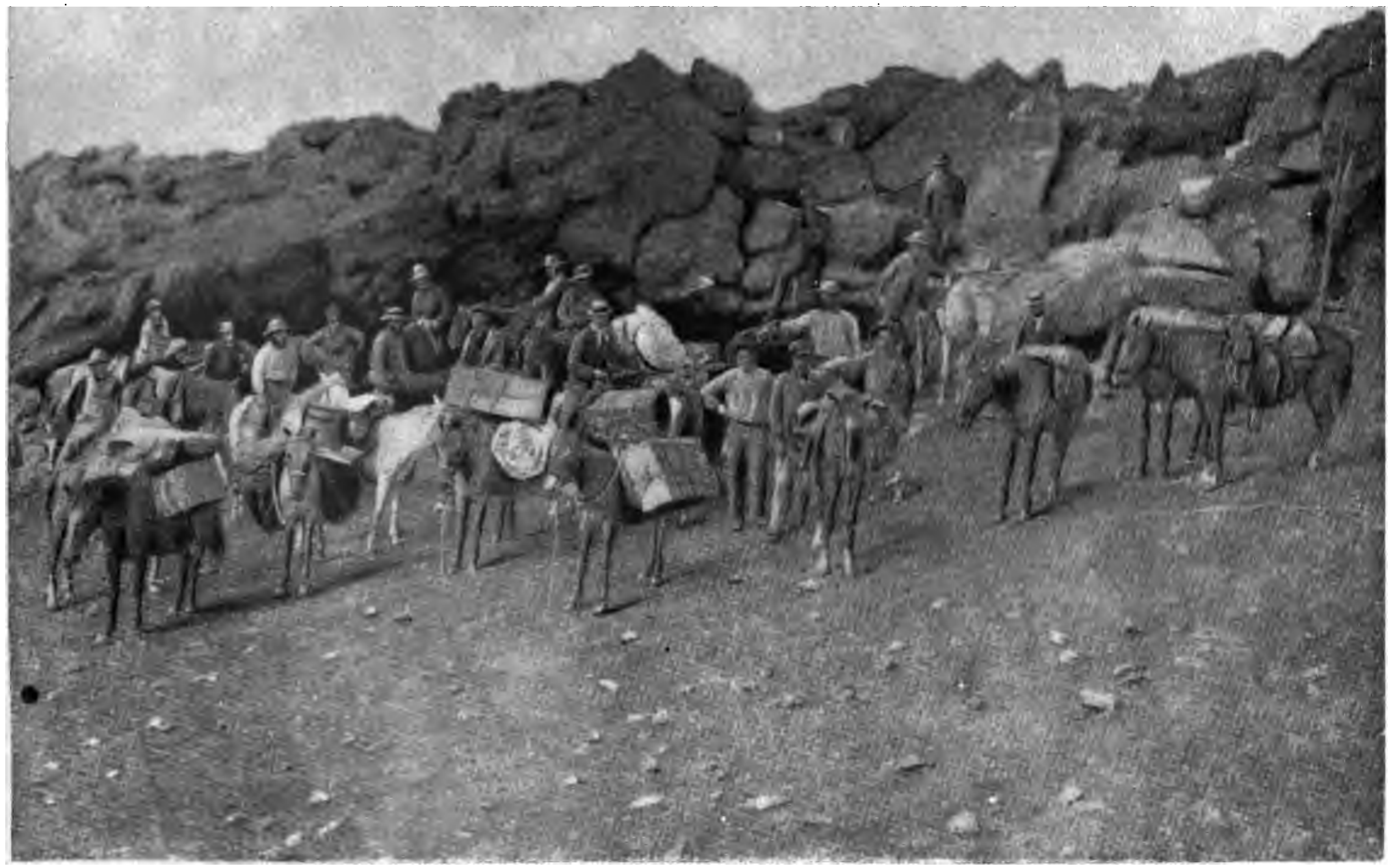
tions were made for time and micrometer value the same evening, and for latitude on January 24, 25, and 26. The last night's work was done with difficulty on account of smoke and dust from Mauna Loa, which was in eruption at the time. The second station was at Kahuku, at the extreme northern point of Oahu. The instruments were shipped by schooner from Honolulu on February 1, the party leaving the following day on horseback and going by the way of Waialua. Observations were completed here on February 12. Circumstances were unfavorable at this station. Clouds and rain prolonged very much the time of observing. On February 9, work lasted from 6.30 p. m. to 4 a. m., with only thirty-three pairs observed. On the 11th, three hours observations gave no more than two pairs. The observing station was situated a mile from our lodging place. At midnight of the 12th, the requisite number of measures being made, the instruments were dismounted and packed, and on Sunday, the 13th, the party rode to Honolulu, a distance of 44 miles, climbing the Pali, a mountain pass 1,200 feet high.

Between February 13 and 22 the time was spent in Honolulu duplicating records, making computations, and preparing the station for gravity measurements. Taking the steamer *Mikahala* on the evening of the 22d, we arrived at Waimea, on the island of Kauai, at noon of the 24th. The pier was constructed in the afternoon (thanks to the energy of Mr. L. H. Stoltz) and observations for time and azimuth were made in the evening. The latitude and micrometer determinations were concluded on March 4, and on the 5th the party and instruments were transferred to Koloa. The transportation of the instruments was a matter of difficulty. An ox-cart of the most primitive kind was the only vehicle available, and the road was in a very bad, not to say dangerous, condition for the transportation of instruments of precision. To guard against possible accident the object glass of the telescope, the eye-piece micrometer, and the levels were removed and packed in a separate box surrounded by cotton. Arriving at Koloa at noon, the instruments were put together, adjusted, and mounted before sundown, and observations were made in the evening. The work was finished on March 16, and on the following day everything was shipped to Hanalei by way of Honolulu. On the 19th the party rode to Kapaa, passing the falls of Waieleele, the road leading through valleys whose sides were covered with guava, cocoa-nut, bread-fruit, fig, and mango trees. The recent rains had swollen the mountain streams and the horses were once obliged to swim, which resulted in a complete wetting of saddle-bags, clothing, and records. From Kapaa to Hanalei consumed the greater part of a day, and we arrived on the evening of March 20, after six hours' travel through a pouring rain. Observations ended on the 31st, and Honolulu was reached on the morning of April 3. This place was occupied for latitude before April 12, besides making duplicates of records and some minor computations.

It was now seen that the six months originally allotted to the work would not suffice. I therefore, at the request of the Surveyor-General, asked for an extension of furlough for three months, to enable us to complete the whole programme. This was granted in a letter from Washington dated April 27, and fixed the time of my return not later than September 15.

On April 12 we took the steamer *Kinau* for Mahukona, Hawaii, arriving on the 13th. Kohala was reached at noon. The pier was constructed on the 15th. In the evening the instrument was put in position, the chronometer correction determined, and thirty-three pairs obtained before midnight. The last observations were made on the 17th and the instruments repacked the following day. On account of the violent wind nearly always prevailing at this point, it was found impossible to pitch a tent for shelter; refuge was taken in an old building formerly used for storing sugar. Leaving Kohala at daybreak of the 19th the harbor of Hilo was reached at midnight.

The rain-fall here is exceptionally large, even for the tropics, as much as 20 feet having been measured in one year. The instruments were mounted on the summit of Halai, and were in position by the evening of the 21st. But only one clear night was experienced during our three weeks' stay. Some one of the party was always standing watch throughout the entire night, so that any partial break in the clouds might be utilized. Thus availing ourselves of every possible occasion, by May 14 about forty pairs had been observed, giving between sixty and seventy independent measures. More observations were desired, but it was not considered advisable to prolong the occupation until the return trip of the steamer. The station was abandoned, therefore, on Saturday, May 14, and on the 15th horses were engaged and the party left for Ka Lae, a distance of about 85 miles. The crater of Kilauea was visited on the 17th and found to be in eruption at two



Resting at "Ana moe haole" (9,300 Feet Elevation). Edge of Crater.

points, although the old lake of 1883 had entirely subsided and disappeared. Passing by Punaluu, Waiohinu, and Kaalualu, Ka Lae was reached at noon of the 21st.

The nearest water suply was eight miles distant. It was brought on mule back; part of the road leading over an "aa" lava flow. The animals could only be sent to drink every two days. The last observations were made on the morning of the 28th, and we were again in Honolulu at 4 p. m. of the 31st. This station was now occupied for gravity, pendulums Nos. 3 and 4 being swung on three days and nights each.

On June 14, the party left for Kailua, Hawaii. This station was finished on the 19th, and on the following day we started for Haiku, via Maalaea Bay, arriving on the 21st. Haiku lies at the base of Haleakala and was occupied for latitude and gravity. The pendulum was started on June 23, and the last star observations were made at 10 p. m. of June 29. At 11 a. m. of the 30th, the ascent of the mountain was begun. The party now consisted of eighteen persons and twenty-five animals besides a cart drawn by twelve oxen. At 5 o'clock Olinda was reached. This lies near the lower limit of the cloud region (4,043 feet) and we encountered heavy fog and rain. A stop was made for the night.

On the morning of July 1, the journey was resumed. After three hours' travel a point was reached beyond which it was impossible to take the cart. The instruments, tents, and provisions were now packed on mules to be carried to the summit, the chronometers, barometers, and thermometers being taken in the hand. Passing through the cloud belt at an elevation of 8,000 feet we met clear weather again and arrived at Ana moe haole, the northwest edge of the crater at 3 p. m. The elevation at this point is considerably over 9,000 feet, and the animals were suffering from the rarity of the atmosphere and from travel over the lava. A rest was taken for an hour (see illustration No. 41), then the route was continued along the edge of the crater, a distance of 3 miles, to Pakaoao, at an elevation of 9,870 feet, the point chosen for the observations.

Before making the ascent it was thought feasible either to make a cavity in the ground in which to swing the pendulum, or to build a small stone house, using the somewhat regular blocks of lava which were said to be in abundance on the summit. Both these projects were soon seen to be impracticable. Fortunately a crevice about 3½ feet wide and 9 feet high was found between two large rocks that possessed the requisite stability and gave promise of quite uniform temperature. This crevice was closed behind by masonry laid in cement, and in front partly by blankets and tarpaulins and partly by masonry (see illustration No. 42), thus permitting ingress and egress in order to start the pendulum and turn it when necessary. Above, dry masonry covered with blankets and a layer of sand was used. The daily range of temperature outside the house and in observing tent was about 30° Fahr. Inside the pendulum house it was 11° centigrade. Although in the tropics and in midsummer, ice was formed nearly every night, the greatest thickness being about one-fourth of an inch. The atmosphere was exceptionally clear—many stars were observed before sundown with a telescope of 2½-inch aperture and magnifying power of sixty. All lava found on one of the peaks is highly magnetic, and differences of several degrees in the declination of the needle within a distance of 2 miles have been noticed on the floor of the crater.

As no provender or water are to be found on the summit, all the animals and all men not necsary were sent down the slope on July 2 to a point where these were to be had.

The first observations were made on July 4; the last on the 12th. The weather was good on the summit, the storms generally occurring several thousand feet below.

Leaving Pakaoao at 8 a. m. of the 13th the party divided, the greater number returning by the way of Olinda and Makawao, and taking the instruments. Mr. Wall and myself with a guide passed down into the crater (see illustrations No. 39 and 43) 2,600 feet below, and out the Kaupo Gap, reaching Kipahulu at 7 p. m. We arrived at Hana on the 15th and closed the work there on the 26th. The weather was very unfavorable. Hana in this respect is a worthy rival of Hilo, and although the rain-fall is much less, the nights are generally cloudy. The difficulty in securing pairs of stars may be judged from the fact that one night's work of eleven hours only gave as many pairs. Arriving at Ka Lae o Ka Ilio on the 28th, the last observations were made on August 1. Seventy-five pairs were observed at this station in seven consecutive hours.

The night's list contained more than one hundred pairs. Generally, it may be said of all the stations that lists covering from eight to ten hours' right ascension, and having about one hundred pairs, were selected in order to be ready for clear weather at any part of the night. These extended lists, however, were only utilized at a few of the windward stations. The work at Kaupo closed the observations for the season, and we took the steamer for Honolulu, arriving there on the 6th. During the remainder of August we were engaged in the Government Office making duplicates, reading chronographic sheets, and making preliminary computations. A transit instrument belonging to the Government Survey was also adjusted and mounted in the new observatory. On the 30th at noon, my connection with the Hawaiian Goverment ceased and I sailed for San Francisco, arriving at 2 p. m. of September 6. The following day, work was resumed on the Coast and Geodetic Survey, preparations being made for the determination of gravity at Lafayette Park Astronomical Station. Observations were begun on September 12 and finished on the 22d. Lick Observatory was the next station to be occupied. On account of the preparations then being made for the formal transfer of the observatory from the Lick trustees to the State, it was impracticable to make the pendulum observations immediately; and it was not until Sunday, October 9, that I left for Mount Hamilton. The intervening time was devoted to reading the chronograph sheets for San Francisco, and doing miscellaneous office work. The operations at Mount Hamilton lasted from October 13 to 26. On the 30th (Sunday) I arrived in San Francisco. That part of the instrumental outfit which was obtained here ten months previously was returned to the Suboffice, and on November 3 I left for Washington, arriving on the evening of the 9th. The instruments shipped by freight from San Francisco on November 1 arrived in Washington on December 7. The Smithsonian Institution (our base station) was occupied between December 8 and December 18. Duplicating records, reading chronograph sheets, and computations consumed the time until January 1, 1888, when the reduction of the whole work, fourteen latitude and six gravity stations, was begun.

TRIANGULATION.

The trigonometrical connections were executed by the Government Survey, and the geodetic latitudes, computations relating thereto, and the sketches of the triangulation were furnished by Professor Alexander. The following extract from the Hawaiian Survey report for 1872 refers to the base measurement on Maui and the angle measurements for the primary triangles connecting the islands:

* * * At the same time they (the U. S. Coast Survey) sent us a complete set of apparatus used in measuring subsidiary base-lines. * * * A base-line was chosen 4½ miles in length, crossing the isthmus of Maui nearly at a right angle, the northern end being 7 feet and the southern 164 feet above mean tide. After grading and clearing the line, and making a preliminary measurement with a long wire, the final measurement with the rods was commenced August 18, 1871 and finished September 8. The mean temperature of the bars during the whole measurement was 94° Fahr. The final corrected length of the line is 6,667.79 metres and the probable error of the measurement is believed not to exceed an inch. * * * The true bearing of the line was determined by a long series of observations at the South Base on the Pole star and a lantern set on the North Base, the exact time being noted by a chronometer. * * * The angles of the primary triangles were measured with a transit theodolite made by Troughton & Simms of London, with a horizontal 12-inch circle reading to one second by two micrometer microscopes, and a vertical 12-inch circle reading to five seconds by two verniers. It is completely fitted for night observations on stars. The telescope has generally been used with a magnifying power of 36, and is remarkably clear. The closing error of the first quadrilateral was one second.

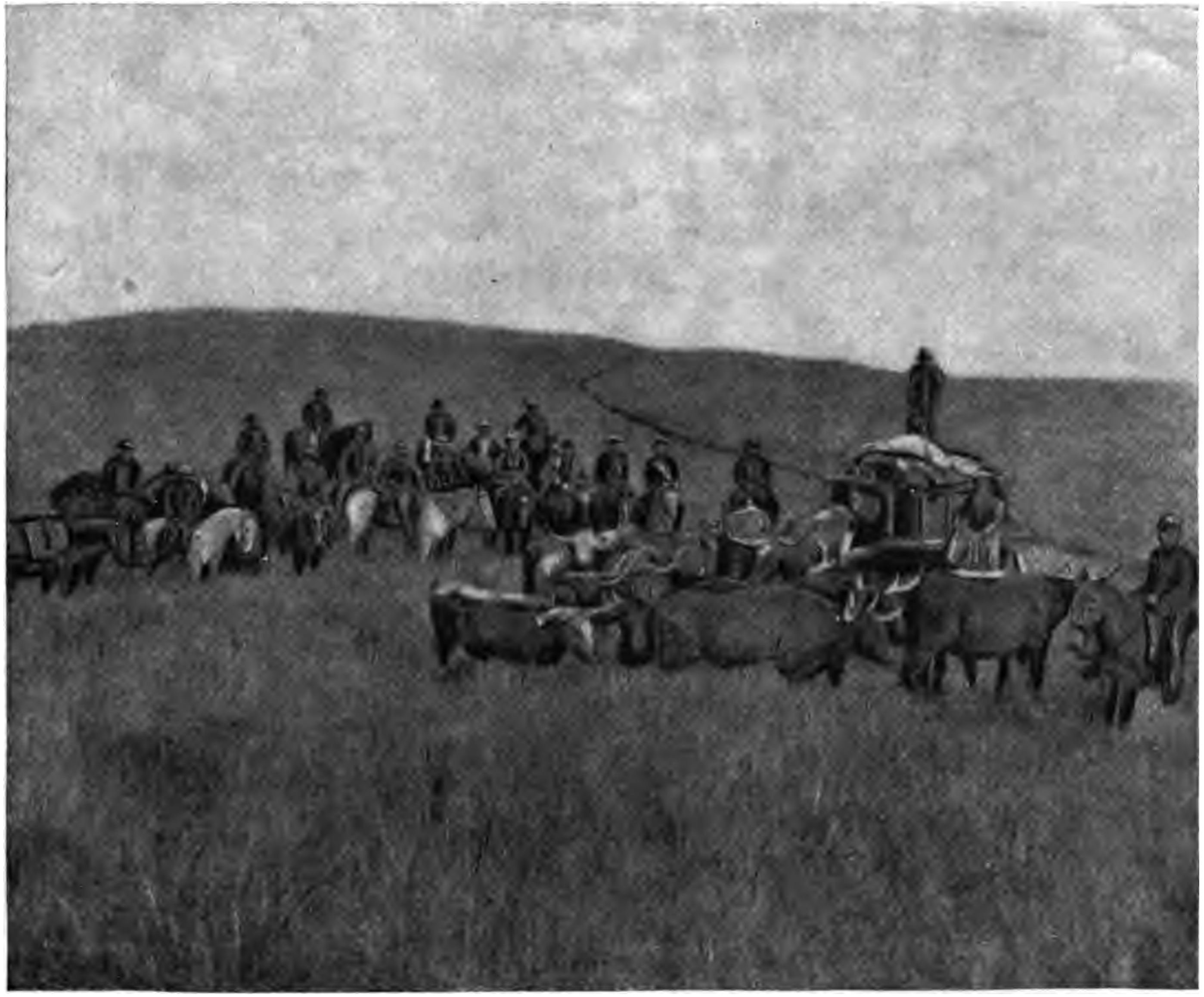
CONNECTIONS BETWEEN THE TRIGONOMETRICAL AND ASTRONOMICAL STATIONS, AND GEODETIC LATITUDES OF THE LATTER

Kauai.

Of this island only a preliminary triangulation exists. It was made with a small instrument and the latitudes on which it was based are only approximative. The geodetic latitudes are derived from Lieutenant Welling's latitude of the Waimea transit of Venus station, given as 21° 57′ 12″.

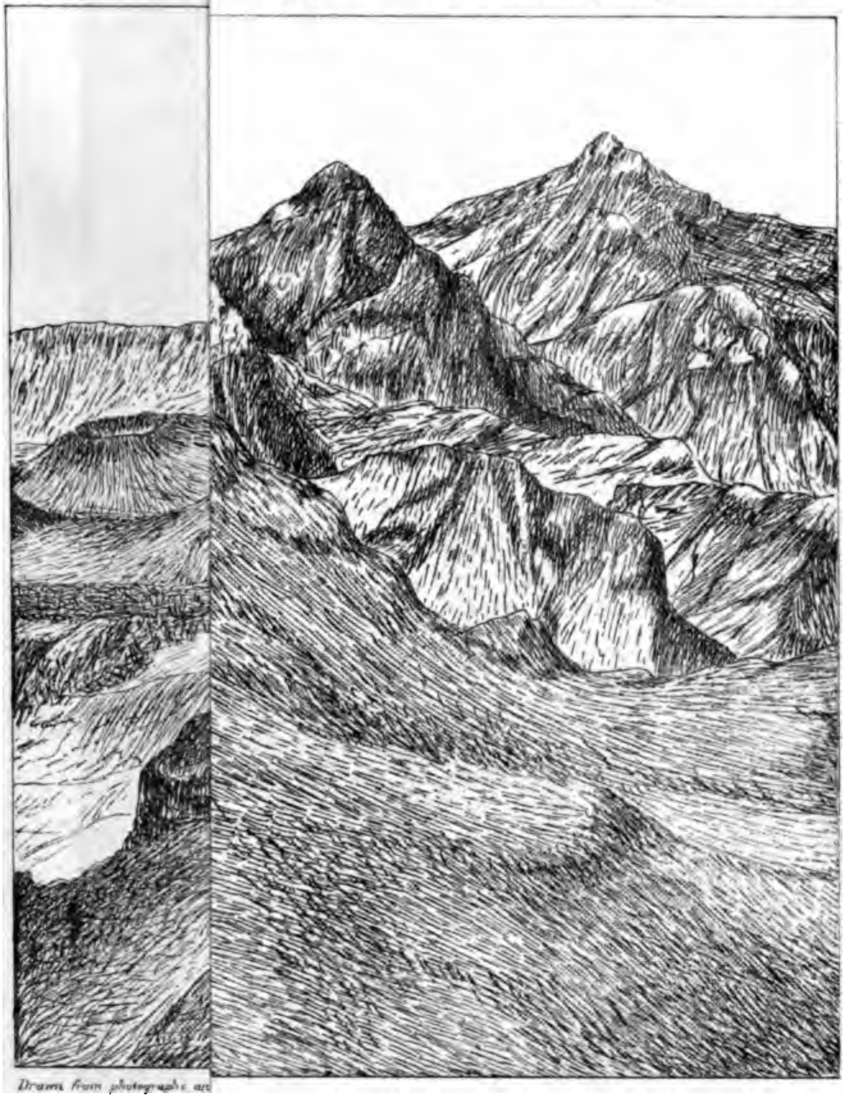
Waimea:

$\varphi = 21^\circ\ 57'\ 12''$. Astronomical station is 11.8 feet due east of transit of Venus pier.



End of Cart Road (5,500 Feet Elevation). Slope of Haleakala.

No. 42 ...oast and Geodetic Survey Report-1888.



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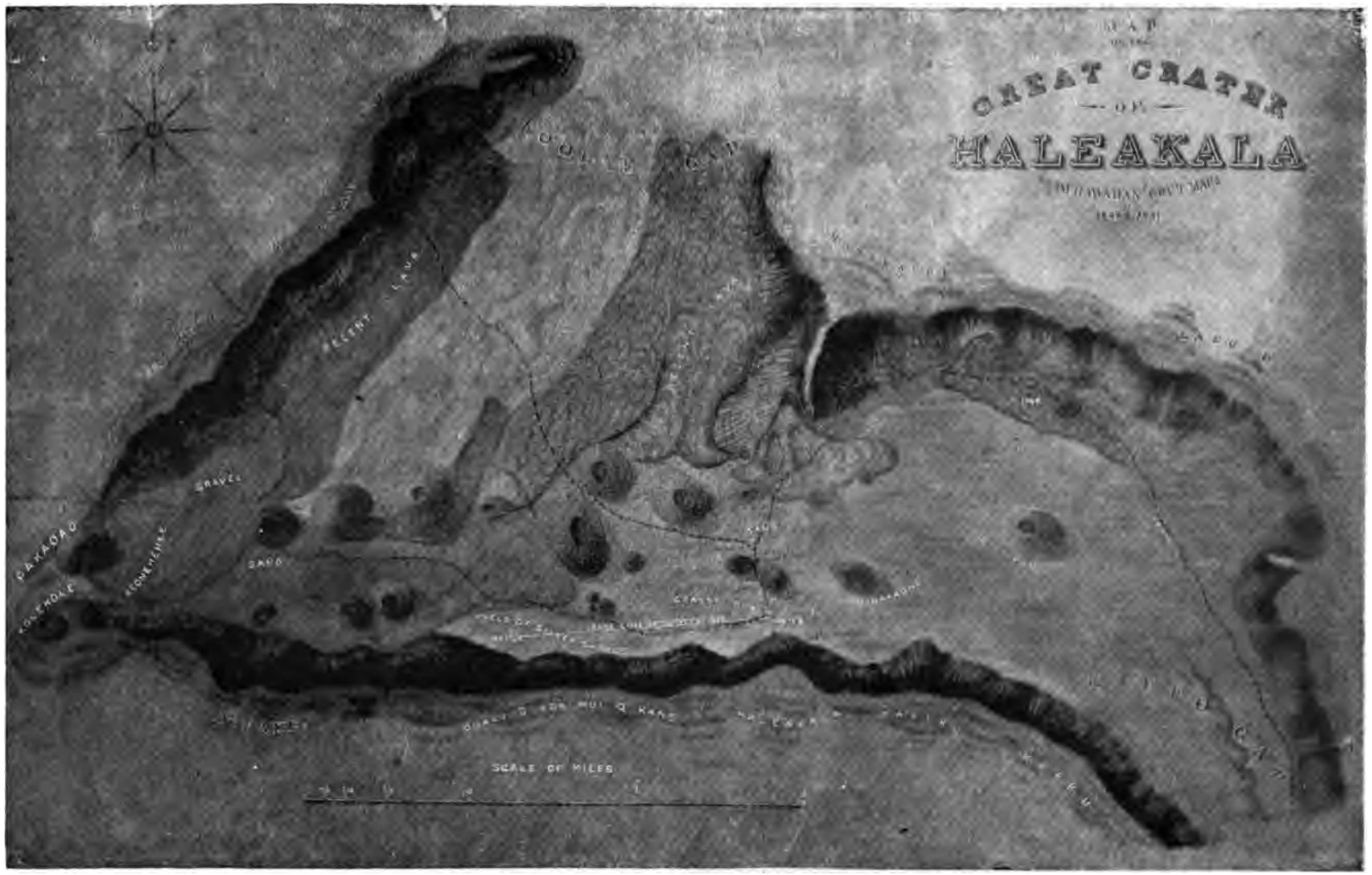


TRAIL FROM PAKAOAO TO KAUPO GAP.

Koloa:

$\varphi = 21° 52' 40''$. Astronomical and trigonometrical stations identical.

Hanalei:

$\varphi = 22° 12' 10''$. Astronomical and trigonometrical stations identical.

Oahu.

The Oahu latitudes are based on Major Tupman's determination of the latitude of the Transit of Venus station in 1874, which is given as $21° 17' 57''.00$.

Puuloa:

$\varphi = 21° 19' 12''.22$. From trigonometrical to astronomical station is 47.2 feet; azimuth is 175° 1′, counting from south around by west.

Kahuku:

$\varphi = 21° 42' 16''.08$. From trigonometrical to astronomical station is 333.6 feet; azimuth 2° 0′.

Honolulu:

$\varphi = 21° 18' 2''.32$. Astronomical station 537.0 feet north and 310.4 east of Transit of Venus pier.

Maui.

The Maui latitudes are based on observations made at North Base by W. D. Alexander in 1872, the latitude adopted for north base being $20° 54' 20''$.

Haiku:

$\varphi = 20° 56' 3''.98$. Trigonometrical to astronomical station = 2,185.4 feet; azimuth is 160° 4′.

Pakaoao (*Haleakala*):

$\varphi = 20° 43' 21''.73$. Trigonometrical to astronomical station, 71.8 feet; azimuth, 145° 12′.

Kaupo (*Ka Lae o ka Ilio*):

$\varphi = 20° 37' 41''.02$. Trigonometrical to astronomical station, 384.8 feet; azimuth, 140° 40′.

Hana (*Kauiki*):

$\varphi = 20° 45' 47''.47$. Trigonometrical and astronomical station identical.

Lahaina (1883):

$\varphi = 20° 52' 53''.19$. Trigonometrical (court-house) to astronomical station, 448.4 feet; azimuth, 146° 18′.

$\varphi = 20° 52' 7''.47$ (carried from Honolulu).

Hawaii.

The latitudes on this island are provisional, being based on the latitude of Puuloa (Kohala) station, which was carried from Maui by the triangle, Haleakala—Kahoolawe—Puuloa; of which only the angle at Haleakala has yet been accurately measured with the 12 inch transit.

Kohala (*Kauhola Pt.*):

$\varphi = 20° 15' 17''.71$. Trigonometrical to astronomical station, 14.3 feet; azimuth, 266° 51′.

Hilo (*Halai*):

$\varphi = 19° 43' 30''.36$. Trigonometrical to astronomical station, 10.0 feet; azimuth, 51° 37′.

Ka Lae:

(Not yet connected.)

Kailua:

$\varphi = 19° 39' 3''.78$. North meridian mark of Transit of Venus station of 1874.

Geodetic connection between Honolulu and Kahuku.

FIRST SERIES OF TRIANGLES.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
1	East Base,*	74 22 18	3.4734891	West Base.
	West Base.	68 58 53	3.6812399	Puu Ohia.
	Puu Ohia.	36 38 49	3.6676978	East Base.
2	West Base.	85 22 15	3.6812399	Puu Ohia.
	Puu Ohia.	66 49 35	4.0110349	Salt Lake.
	Salt Lake.	27 48 10	3.9759190	West Base.
3	Puu Ohia.	51 47 35	4.0110349	Salt Lake.
	Salt Lake.	23 25 55	3.9209397	Puowaina.
	Puowaina.	104 46 30	3.6251491	Puu Ohia.
4	Salt Lake.	103 29 47	3.9209397	Puowaina.
	Puowaina.	36 53 39	4.1042629	Puuloa.
	Puuloa.	39 36 34	3.8948212	Salt Lake.
5	Salt Lake.	56 43 00	3.8948212	Puuloa.
	Puuloa.	63 28 05	3.8802911	Ewa church.
	Ewa church.	59 48 55	3.9097723	Salt Lake.
6	Puuloa.	39 07 14	3.8802911	Ewa church.
	Honouliuli.	73 25 12	3.8642221	Puuloa.
	Ewa church.	67 27 34	3.6987321	Honouliuli.
6B	Salt Lake.	37 05 24	3.8948212	Puuloa.
	Puuloa.	102 35 16	3.864226	Honouliuli.
	Honouliuli.	40 19 20	4.073292	Salt Lake.
7	Ewa church.	[illegible] 47 33	3.6987321	Honouliuli.
	Honouliuli.	88 38 04	4.0841027	Maunauna.
	Maunauna.	22 34 23	4.1144346	Ewa church.
8	Honouliuli.	36 57 46	4.0841027	Maunauna.
	Maunauna.	45 58 52	3.8664928	Waipio Mauka.
	Waipio Mauka.	97 03 22	3.9442002	Honouliuli.
9	Ewa church.	24 59 35	4.1144346	Maunauna.
	Maunauna.	23 24 30	3.8664763	Waipio Mauka.
	Waipio Mauka.	131 35 55	3.8397391	Ewa church.
10	Ewa church.	93 47 07	3.6987321	Honouliuli.
	Honouliuli.	51 40 20	3.9441872	Waipio Mauka.
	Waipio Mauka.	34 32 33	3.8397153	Ewa church.

*Azimuth from West Base to East Base 291° 29′ 35″.

***Geodetic connection between Honolulu and Kahuku*—Continued.**

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
11	Maunauna.	120 05 51	3.8664846	Waipio Mauka (Av.).
	Waipio Mauka.	27 37 30	4.0760298	Maili.
	Maili.	32 16 39	3.8051476	Maunauna.
12	Waipio Mauka.	55 57 38	4.0760298	Maili.
	Maili.	62 19 44	4.0496410	Peahinaia.
	Peahinaia.	61 42 38	4.0785199	Waipio Mauka.
13	Maunauna.	56 53 54	3.8051476	Maili.
	Maili.	94 36 22	4.0496368	Peahinaia.
	Peahinaia.	28 29 44	4.1251419	Maunauna.
14	Waipio Mauka.	83 35 08	3.8664846	Maunauna.
	Maunauna.	63 11 55	4.0785117	Peahinaia.
	Peahinaia.	33 12 57	4.1251397	Waipio Mauka.
15	Maili.	121 40 12	4.0496368	Peahinaia.
	Peahinaia.	27 20 06	4.2678341	Mokuleia.
	Mokuleia.	30 59 42	3.9998552	Maili.
16	Maili.	42 20 12	3.9998552	Mokuleia.
	Mokuleia.	61 09 48	3.8403522	Puaena.
	Puaena.	76 30 00	3.9545269	Maili.
17	Maili.	81 44 10	3.9998552	Mokuleia.
	Mokuleia.	67 55 45	4.2219872	Kawela.
	Kawela.	30 20 05	4.2634687	Maili.
18	Maili.	69 01 27	3.9998552	Mokuleia.
	Mokuleia.	73 33 53	4.1865098	Pupukea.
	Pupukea.	37 24 40	4.1981698	Maili.
19	Maili.	26 41 15	3.9545269	Puaena.
	Puaena.	125 42 35	3.9400944	Pupukea.
	Pupukea.	27 36 10	4.1981757	Maili.
20	Maili.	12 42 43	4.1981757	Pupukea.
	Pupukea.	117 36 12	3.6584588	Kawela.
	Kawela.	49 41 05	4.2634586	Maili.
21	Pupukea.	38 36 19	3.6584588	Kawela.
	Kawela.	56 01 51	3.4550330	Waialee.
	Waialee.	85 21 50	3.5786138	Pupukea.

Geodetic connection between Honolulu and Kahuku—Continued.

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
22	Kawela.	67 25 30	3.4550330	Waialee.
	Waialee.	81 48 40	3.7115656	Kahuku.
	Kahuku.	30 45 50	3.7417353	Kawela.
23	Kawela.	46 00 00	3.7417353	Kahuku.
	Kahuku.	23 56 44	3.6258340	Puu Ki.
	Puu Ki.	110 03 16	3.3772851	Kawela.
24	Kahuku.	43 49 56	3.6258340	Puu Ki.
	Puu Ki.	111 03 40	3.8386065	Laie.
	Laie.	25 06 24	3.9681296	Kahuku.

SECOND SERIES OF TRIANGLES.

1	East Base.	74 22 18	3.4734891	West Base.
	West Base.	68 58 53	3.6812399	Puu Ohia.
	Puu Ohia.	36 38 49	3.6676978	East Base.
2	West Base.	99 20 37	3.6812399	Puu Ohia.
	Puu Ohia.	44 46 54	3.9075307	Leahi.
	Leahi.	35 52 29	3.7611551	West Base.
3	West Base.	96 15 41	3.7611551	Leahi.
	Leahi.	51 05 05	4.0266979	Konahuanui.
	Konahuanui.	32 38 14	3.9203320	West Base.
4	West Base.	74 54 29	3.6812399	Puu Ohia.
	Puu Ohia.	57 20 13	3.7966022	Kaimuki.
	Kaimuki.	47 45 18	3.7370851	West Base.
5	West Base.	71 50 33	3.7370851	Kaimuki.
	Kaimuki.	70 05 28	3.9249164	Konahuanui.
	Konahuanui.	38 03 59	3.9203364	West Base.
6	Leahi.	58 55 33	4.0266979	Konahuanui.
	Konahuanui.	83 32 30	4.1746572	Makapuu.
	Makapuu.	37 31 57	4.2391650	Leahi.
7	Konahuanui.	81 36 56	4.1746572	Makapuu.
	Makapuu.	43 38 52	4.2580303	Mokapu.
	Mokapu.	54 44 12	4.1016866	Konahuanui.
8	Makapuu.	29 37 22	4.2580303	Kailua.
	Mokapu.	56 44 38	3.9528837	Coolidge's Station.
	Kailua.	93 38 00	4.1812287	Mokapu.

Geodetic connections between Honolulu and Kahuku—Continued.

SECOND SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
9	Mokapu.	26 11 27	3.9528837	Kailua.
	Kailua.	85 49 18	3.6305515	Coolidge's Station.
	Coolidge's Station.	67 59 15	3.9846004	Mokapu.
10	Mokapu.	57 26 08	3.9846004	Coolidge's Station.
	Coolidge's Station.	86 06 14	4.1363347	Puu Ohulehule.
	Puu Ohulehule.	36 27 38	4.2096122	Mokapu.
11	Mokapu.	24 38 02	4.2006122	Puu Ohulehule.
	Puu Ohulehule.	129 54 49	4.1963305	Laie.
	Laie.	25 27 09	4.4611861	Mokapu.

The Peaks of Konahuanui and Puu Ohulehule were not occupied with instruments.
Latitude of Laie, first series, 21° 38′ 40″.65; second series, 21° 38′ 40″.53.
Azimuth from Laie to Mokapu, first series, 318° 1′ 24″.6; second series, 318° 1′ 24″.1.

Summary.

Station.	Latitudes.	
	Geodetic.	Astronomic.
	° ′ ″	° ′ ″
Honolulu Observatory.	21 18 2.3	21 18 2.5
Kahuku, trigonometric.	21 42 19.2	----------
Kahuku Observatory.	21 42 16.1	21 43 6.1
Difference.	0 24 13.8	0 25 3.6
Deflection of plumb-line.	----------	0 0 24.9

Geographical positions.

OAHU.

Station.	First series. φ	First series. λ	Station.	Second series. φ	Second series. λ
	° ′ ″	° ′ ″		° ′ ″	° ′ ″
West Base.	21 17 48.16	157 50 55.79	West Base.		
Puu Ohia.	21 19 43.20	49 03.22	Puu Ohia.		
Salt Lake.	21 21 33.62	54 39.17	East Base.	21 17 12.70	157 49 19.75
Puuloa.	21 19 11.76	58 25.64	Konahuanui.	21 20 57.58	157 47 29.44
Honouliuli.	21 21 55.87	158 01 29.45	Leahi.	21 15 20.59	157 48 52.17
Ewa church.	21 23 16.62	157 58 58.89	Makapuu.	21 18 15.75	157 39 20.16
Waipio Mauka.	21 26 38.67	158 00 44.18	Mokapu.	21 27 01.07	157 44 04.68
Maunauna.	21 27 42.86	04 50.23	Coolidge.	21 24 05.61	157 48 42.59
Peahinaia.	21 33 03.30	157 59 37.83	Puu Ohulehule.	21 30 30.59	157 52 41.19
Maili.	21 31 03.81	158 05 45.93	Laie.	21 38 40.53	157 55 16.51
Mokuleia.	21 34 29.10	10 15.33			
Puaena.	21 35 53.45	06 32.14			
Pupukea.	21 39 11.30	02 54.46			
Kawela.	21 39 35.44	00 18.14			
Waialee.	21 40 42.86	01 26.22			
Kahuku.	21 42 19.21	157 58 59.79			
Puuki.	21 40 01.82	59 00.17			
Laie.	21 38 40.65	55 16.57			

Geodetic connection between Haiku and Kaupo.

FIRST SERIES OF TRIANGLES.

	Station.	Angle.	Distance in metres; logs.	To—	Latitudes for Col. I.
		° ′ ″			° ′ ″
1	North Base.*	100 25 07.5	3.8239822	South Base.*	20 54 20.0
	South Base.	59 25 23	4.2794300	Piiholo.	20 51 7.8
	Piiholo.	20 09 29.5	4.2216265	North Base.	20 51 39.8
2	North Base.	29 17 39	4.2216265	Piiholo.	
	Piiholo.	45 11 15	3.9273226	Haiku.	
	Haiku.	105 31 06	4.0886547	North Base.	20 55 43.6
3	South Base.	34 16 21	4.2794294	Piiholo.	
	Piiholo.	103 41 15	4.2041892	White Hill.	
	White Hill.	42 02 24	4.4410687	South Base.	20 43 21.15
4	Piiholo.	25 55 32	4.2041892	White Hill.	
	White Hill.	88 49 20	3.8867102	Hanakauhi.	
	Hanakauhi.	65 15 08	4.2459353	Piiholo.	20 44 37.6

*Azimuth North Base to South Base 27° 35′ 25″.0.

Geodetic connection between Haiku and Kaupo—Continued.

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To--	Latitudes for Col. I.
		° ′ ″			° ′ ″
5	White Hill.	27 22 45	3.8867102	Hanakauhi.	
	Hanekauhi.	82 02 20	3.574786	Haleakala 2.	
	Haleakala 2.	70 34 55	3.907938	White Hill.	20 42 37.2
6	White Hill 2.	18 58 00	3.907938	Haleakala 2.	
	Haleakala 2.	126 00 45	3.661028	Palaha.	
	Palaha.	35 01 15	4.057010	White Hill.	20 44 21.4
7	Haleakala 2.	113 40 00	3.661028	Palaha.	
	Palaha.	46 33 30	4.093537	Ka Lae o Ka Ilio.	
	Ka Lae o Ka Ilio (Kaupo).	19 46 30	3.992672	Haleakala 2.	20 37 38.1

SECOND SERIES OF TRIANGLES.

1	North Base.	80 37 23.5	3.8239821	South Base.	20 54 20.0
	South Base.	76 55 06.5	4.2360637	Puu Pane.	20 51 7.8
	Puu Pane.	22 27 30	4.2304866	North Base.	20 48 47.3
2	North Base.	19 47 43.5	4.2304866	Puu Pane.	
	Puu Pane.	76 45 24	3.7630998	Piiholo.	
	Piiholo.	83 26 52.5	4.2216265	North Base.	20 51 39.8
3	North Base.	29 17 39	4.2216265	Piiholo.	
	Piiholo.	45 11 15	3.9273226	Haiku.	
	Haiku.	105 31 06	4.0886547	North Base.	20 55 43.6
4	South Base.	38 36 50	4.2360637	Puu Pane.	
	Puu Pane.	62 39 17	4.0397505	Puu-o-Kali.	
	Puu-o-Kali.	78 43 53	4.1930553	South Base.	20 44 22.1
5	South Base.	48 18 22	4.2360637	Puu Pane.	
	Puu Pane.	79 05 02	4.2091099	Puu Io.	
	Puu Io.	52 36 36	4.3280282	South Base.	20 40 52.1
6	Puu Pane.	16 25 45	4.2091099	Puu Io.	
	Puu Io.	28 38 58	3.8105550	Puu-o-Kali.	
	Puu-o-Kali.	134 55 17	4.0397726	Puu Pane.	
7	Puu-o-Kali.	36 13 16	3.8105550	Puu Io.	
	Puu Io.	94 35 50	3.7030981	Polipoli.	
	Polipoli.	49 10 54	3.9301788	Puu-o-Kali.	20 40 48.1
8	South Base.	20 01 07	4.3280282	Puu Io.	
	Puu Io.	93 02 20	3.8986264	Puu Olai.	
	Puu Olai.	66 56 33	4.3635763	South Base.	20 38 42.6

***Geodetic connection between Haiku and Kaupo*—Continued.**

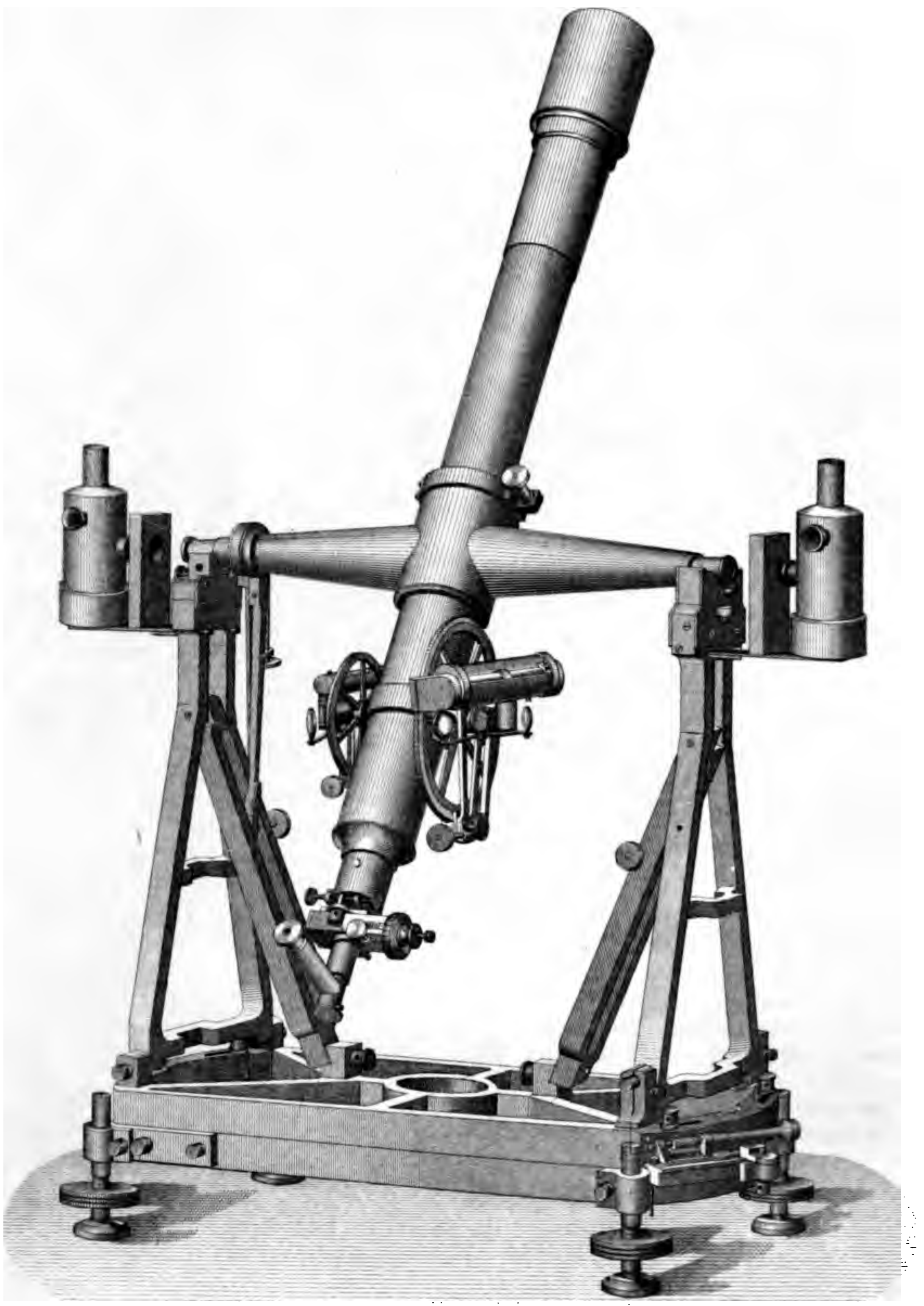
SECOND SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—	Latitudes for Col. I.
		° ′ ″			° ′ ″
9	Puu Io.	148 24 12	3.8986264	Puu Olai.	
	Puu Olai.	12 12 51	4.0969330	Polipoli.	
	Polipoli.	19 22 57	3.7031012	Puu Io.	
10	Puu Olai.	22 12 10	4.0969330	Polipoli.	
	Polipoli.	21 58 00	3.8311961	Puu Mahoe.	
	Puu Mahoe.	135 49 50	3.8267852	Puu Olai.	20 38 26.6
11	Polipoli.	20 34 09	3.8311961	Puu Mahoe.	
	Puu Mahoe.	99 32 42	3.4398912	Pimoe.	
	Pimoe.	59 53 09	3.8881117	Polipoli.	20 37 9.3
12	Polipoli.	53 07 50	3.8881117	Pimoe.	
	Pimoe.	57 58 50	3.8213768	Lualailua.	
	Lualailua.	68 53 20	3.8466126	Polipoli.	20 37 18.8
13	Pimoe.	24 04 45	3.8213768	Lualailua.	
	Lualailua.	103 30 00	3.532937	Shore D.	
	Shore D.	52 25 15	3.910110	Pimoe.	20 35 32.2
14	Lualailua.	112 30 00	3.532937	Shore D.	
	Shore D.	48 12 20	3.979482	Puu Pane 2.	
	Puu Pane 2.	19 17 40	3.886338	Lualailua.	20 39 54.7
15	Shore D.	44 36 35	3.979482	Puu Pane 2.	
	Puu Pane 2.	102 05 00	4.086318	Ka Lae-o-ka Ilio.	
	Ka Lae-o-ka Ilio (Kaupo).	33 18 25	4.230081	Shore D.	20 37 38.1

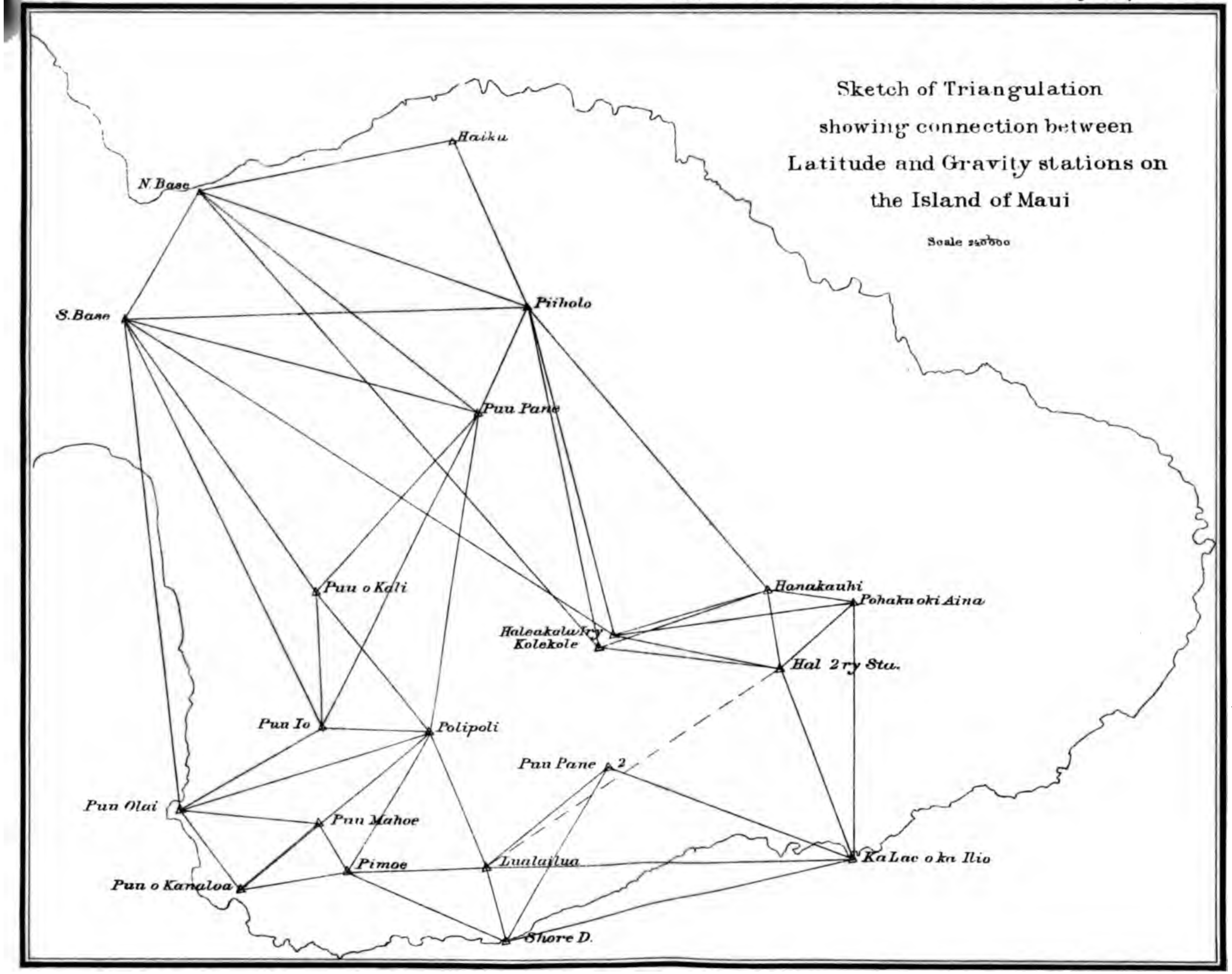
In the first series, the stations were occupied with the 12-inch transit reading to single seconds, except Hanakauhi, Haleakala 2, and Palaha, which were occupied with 5-inch transits. White Hill is also called Pakaoao, and Palaha is the "Pohaku-oki-aina," *i. e.*, the rock where the boundaries of eight districts meet.

In the second series, the angles of the first ten triangles were measured with the 12-inch transit, except those at Polipoli. The remaining angles of the series were measured with small instruments.

Geodetic latitude of Ka Lae-o ka Ilio, 1st series, 20° 37′ 38″.06; 2d series, 38″.07.



Meridian Telescope.
TRANSIT AND EQUAL ALTITUDE INSTRUMENT.


Sketch of Triangulation
showing connection between
Latitude and Gravity stations on
the Island of Maui
Scale
Haiku
N. Base
S. Base
Piiholo
Puu Pane
Puu o Kali
Haleakala
Kolekole
Hanakauhi
Pohaku oki Aina
Hal 2ry Sta.
Puu Io
Polipoli
Puu Pane 2
Puu Olai
Puu Mahoe
Pimoe
Lualailua
Puu o Kanaloa
Ka Lae o ka Ilio
Shore D.

Summary.

Station.	Latitudes. Geodetic.	Latitudes. Astronomic.
	° ′ ″	° ′ ″
Haiku:		
Trigonometric.	20 55 43.6	
Observatory.	20 56 4.0	20 56 2.6
Kaupo:		
Trigonometric.	20 37 38.1	
Observatory.	20 37 41.0	20 36 40.8
Difference.	18 23.0	19 21.8
Deflection of plumb-line.	----------	0 29.4
Pakaoao:		
Trigonometric.	20 43 21.2	
Observatory.	20 43 21.6	21 42 51.0

LATITUDE.

The method employed was that described in the U. S. Coast and Geodetic Survey Report for 1880, Appendix No. 14. Pairs of stars were chosen whose zenith distances ranged from 0° to 50° and whose differences of zenith distances were not greater than 44 minutes. An examination of eleven stations where stars were observed up to these limits shows that the results from such stars are generally as satisfactory as those from normal pairs. The mean difference between the results for low stars and normal ones is not greater than the probable error of observation. Ninety seconds between pairs, and 30 seconds between stars of the same pair, was the shortest time allowed. The stars were chosen from Appendix No. 7, Report for 1876, and from the catalogue of 12,441 stars observed at the Cape of Good Hope by Stone. These two lists will furnish pairs at the rate of eight or ten per hour for latitudes near 20°. The instrument used was meridian telescope No. 1 (illustration No. 47).

The reductions of the stars in declination from the mean place at 1887.0 to the apparent place at the time of observation were effected by the use of the following formulæ:

$$-gdG \sin (G+\alpha)+dg \cos (G+\alpha)$$
$$[-hdH \sin(H+\alpha)+dh \cos (H+\alpha)] \sin \delta$$
$$di \cos \delta$$

Where the letters have the same signification as in the American Ephemeris. By this method the computations were considerably abridged with no sacrifice of essential accuracy. The apparent places for thirty pairs on two dates can thus be derived in seven hours.

The above formulæ are derived from the ordinary reduction formula by differentiation, considering the tabular differences of the quantities that vary with the date as the differential co-efficients of the quantities with respect to the time at the date already computed. The method is explained in detail in the Journal of the Franklin Institute, April, 1889, and also in Appendix No. 13 to this volume.

The mean declinations of the stars for the epoch 1887.0 were furnished by the Coast and Geodetic Survey Office. The treatment of the subject is set forth by Mr. C. A. Schott in the following extract from a communication to the Assistant in charge of the Office:

"The method of reduction and combination for obtaining mean places of stars (in declination) followed in the Computing Division of the Coast and Geodetic Survey, depends mainly on the investigation made by Lewis Boss in connection with the U. S. Northern Boundary Survey and as presented in his report of February, 1877, on the declination of fixed stars.

"The places obtained by the individual catalogues are weighted on a scale nearly identical with that used by Boss (pp. 160, 161 of his report) or by Auwers in his fundamental catalogue. For catalogues later than 1835 these weights vary between 0.5 and 6.

"With respect to the number of observations, n, the relative weights are put proportional to $\left(1 + \frac{6}{n}\right)^{-1}$ so that for instance 1, 6, and 60 observations would receive the relative weights 0.1, 0.5, and 0.9 nearly.

"The probable error of the unit of weight is taken equal to $\pm 0.''37$, a value intermediate between those of Boss and Auwers; that of the declination at the mean epoch is ± 0.37 times the $(\text{sum})^{-\frac{1}{2}}$ of the weights; that of the proper motion is derived from the weights as explained below, and the tabular probable error is obtained by combining the last two.

"The systematic corrections to the declinations are taken from the report of Boss, page 175 *et seq.*, with some additional columns for special catalogues; these corrections depend on the declination argument alone, those depending on right ascensions being not considered.

"Unless the proper motion of a star (in declination) is given in Auwer's catalogues, it is specially made out from discussion of the individual values for the declination by each catalogue with application of the method of least squares and the use of weights, which latter depend on the square of the difference of time elapsed between some adopted average epoch (say 1855) and the epoch of the particular catalogue.

"When, however, there are no later observations than are used in the Northern Boundary Survey Catalogue of Boss, Newcomb's Zodiacal Stars, or Safford's declinations, or where later observations correspond pretty closely with those authorities, no such special calculation was believed necessary.

"In accordance with the above principles, the mean places of stars required by the Coast and Geodetic Survey are now made out and presented in tabular form by Mr. H. Farquhar, of the Computing Division, who has special charge of this class of computations."

Inclination of micrometer thread.

At Puuloa, Kahuku, and Waimea, the micrometer thread was not coincident with the tangent to the star's path when crossing the meridian. As this defect could not be remedied immediately, it became necessary to determine its inclination in order to correct the micrometer readings for those stars that were not observed at culmination. This was done by bisecting a number of stars at each station either before or after culmination, and noting the time and readings of the micrometer, and comparing these with the regular meridian observation. For north stars the extra bisections were made after culmination and for south stars before it; the position of the rack for counting the micrometer turns, which encroached considerably on the east side of the field, made this course necessary.

The reading of the micrometer was first corrected for the change in altitude of the star between the point of observation and the meridian. The difference between this corrected reading and the reading at culmination gave the error due to the inclination of the micrometer for this particular distance from the meridian and for a star of this declination. Dividing by the time in seconds and multiplying by the secant of the declination, we have the error in reading when an equatorial star is bisected one second from the meridian. This was done for a number of stars and the mean correction found to be 0.062 divisions.

The correction to be applied to any particular star would therefore be $0^{d}.062\ t \cos \delta$ and the correction to the latitude in seconds of arc $0''.02\ t \cos \delta$; t being the distance from culmination expressed in seconds of time. For stars bisected before the meridian the correction is negative, while for those after the meridian it is positive.

Micrometer.

The value of one revolution of the micrometer screw was determined eleven times during the course of the work. Five times, Polaris was used near west elongation, and the times were noted by the eye-and-ear method to the nearest second of time. The chronograph was used six times, somewhat faster moving stars being chosen, and the recorded times were read off to the nearest tenth of a second. The following table gives the stations, method, time, and results of the separate determinations:

Station.	Method.	Month.	Individual values.	Values for station.
			$''$	$''$
Waimea.	Eye and ear.	February.	64.38	64.36
Do.	Do.	Do.	.34	
Hanalei.	Do.	March.	.30	
Do.	Do.	Do.	.31	.31
Do.	Do.	Do.	.32	
Honolulu.	Chronograph.	June.	.36	
Do.	Do.	Do.	.37	.36
Do.	Do.	Do.	.35	
Pakaoao.	Do.	July.	.35	
Do.	Do.	Do.	.37	.37
Do.	Do.	Do.	.40	

Mean adopted value = 64′′.350 ± 0′′.01.

Level.

The value of one division of the level was determined at Hilo by means of the eye-piece micrometer.

Four determinations were made on different parts of the screw with the following results:

			Rev.		Rev.
From 0 turns to 10 turns	1 division	=	.01423	±	.00009
From 10 turns to 20 turns		=	46	±	10
From 20 turns to 30 turns		=	25	±	13
From 30 turns to 40 turns		=	31	±	07
Adopted value	1 division	=	.01429	±	.00005

A previous determination at Kahuku Oahu gave 0.01428 revolutions, so the Hilo value is accepted, and we have finally 1 division of level, 0′′.920.

Discussion of the results.

Assuming that the probable error of observation is the same for each pair of stars, its mean value from all the pairs is given by the formula:

$$e_0 = \sqrt{\frac{0.455 \, \Sigma \Delta^2}{n - m}}$$

Where $\Sigma \Delta^2$ = sum of all the residuals obtained by comparing each mean result with the individual values for that pair; m = the number of pairs having at least two observations, and n = the total number of observations on the m pairs.

Admitting that e_0 represents the best attainable value for the probable error of observation of any pair, the probable error of any mean result from a pair will be

$$\epsilon_{,} = \sqrt{\frac{0.455\ \Sigma \Delta^2}{n_{,}(n-m)}} = \frac{e_0}{\sqrt{n_{,}}}$$

Where $n_{,}$ is the number of observations on that particular pair.

If $p =$ the total number of pairs observed at a station, a mean value of ϵ will be given by the formula

$$\epsilon = \sqrt{\frac{e_0}{p-1}\left[\frac{1}{n}\right]}$$

$\left[\frac{1}{n}\right]$ being the sum of the reciprocals of the separate values of n.

The probable error of the latitude (φ) from any individual pair being given by

$$e_\phi = \sqrt{\frac{.455\ \Sigma \Delta \varphi^2}{p-1}}$$

the probable error of the mean of two declinations results from the formula

$$e_\delta = \sqrt{e_\phi^2 - \epsilon^2}$$

The declinations of each of the stars of a pair are regarded as affected with the same probable error. The weight (w) assigned to each value of φ depends on the accuracy of the star's places and the number of times the pair was observed.

Hence the scale for weights is determined by

$$w = \frac{n}{ne_\delta^2 + e_0^2}$$

Where a star enters into combination with several others, these weights are modified by multiplying by $\frac{2}{c+1}$ where c is the number of pairs in the entire combination.

The finally adopted latitude is

$$\varphi_0 = \frac{\Sigma w \varphi}{\Sigma w}$$

with a probable error of

$$e_\phi = \sqrt{\frac{0.455\ \Sigma w \Delta \varphi^2}{(p-1)\ \Sigma w}}$$

Assuming that the probable error of observation (e_0) is equal to 0''.50 and the probable error of a single declination 0''.30, the following table has been calculated showing the relations between the number of pairs, the number of nights, and the probable error of the mean resulting latitude:

Number of nights of observations.	Number of pairs observed.					
	5	10	15	20	25	30
	Resulting probable error of mean result.					
	''	''	''	''	''	''
3	0.17	0.12	0.09	0.08	0.07	0.07
5	.15	.10	.08	.07	.06	.06
7	.13	.09	.07	.06	.06	.05

The following tables give the summary of results for all the stations and the separate values for each one of them:

Summary of results.

Station.	Latitude.	Number of determinations.	Number of pairs.	Number of nights.	ϵ_0	ϵ	ϵ_δ	w	ϵ_ϕ
	° ′ ″				″	″	″		″
Puuloa.	21 19 15.6	74	29	3	±0.56	±0.37	±0.30	2.50	±0.09
Kahuku.	21 43 06.1	88	36	4	.46	.33	.48	2.27	.10
Waimea.	21 57 00.8	120	30	7	.45	.24	.25	3.80	.06
Koloa.	21 52 13.2	107	31	6	.43	.24	.50	2.26	.10
Hanalei.	22 12 56.5	97	33	6	.46	.28	.32	3.24	.07
Honolulu.	21 18 02.5	116	33	4	.43	.24	.46	2.52	.09
Kohala.	20 15 29.3	82	33	3	.42	.28	.59	1.93	.11
Hilo.	19 43 11.2	64	41	7	.53	.48	.49	1.93	.10
Ka Lae.	18 53 51.7	85	37	5	.51	.36	.56	1.71	.11
Kailua.	19 38 20.9	43	35	4	.51	.48	.67	1.41	.14
Haiku.	20 56 02.6	75	38	5	.53	.37	.49	1.95	.12
Pakaoao.	20 42 51.0	62	27	5	.47	.38	.50	2.11	.11
Hana.	20 45 38.9	68	47	5	.53	.48	.57	1.63	.11
Kaupo.	20 36 40.8	90	35	6	.68	.46	.49	1.42	.12
Means.	----------------	84	34	5	0.50	0.36	0.48	2.19	0.10

ϵ_0 = probable error of single individual result for φ from one pair of stars.
ϵ = probable error of φ from observations on one pair.
ϵ_δ = probable error of mean of two declinations.
w = weight of φ from one observation.
ϵ_ϕ = probable error of resulting latitude from all observations.

Summary of results—Continued.

PUULOA. $\varphi=21° 19'.3$.

Star numbers.		Values from single observations.			Means.
		"	"	"	"
255	264	15.10	14.95	14.85	14.97
264	277	14.82	14.46	15.31	14.86
289	303	17.33	16.54	14.76	16.21
348	354	16.21	17.15	15.86	16.41
382	386	15.31	16.08	15.76	15.72
397	418	14.02	------	------	14.02
471	478	14.57	14.58	15.20	14.78
484	496	15.96	14.86	13.74	14.85
504	506	14.47	17.37	16.68	16.17
551	557	16.14	------	------	16.14
567	573	15.50	15.40	12.93	14.61
2640	600	16.00	15.17	17.81	16.33
615	620	14.72	15.84	15.78	15.45
630	637	15.98	15.83	------	15.90
652	654	15.49	15.06	14.24	14.93
662	672	15.08	14.73	15.99	15.27
686	689	15.02	15.75	------	15.38
706	715	16.84	15.81	------	16.32
729	3745	15.29	17.40	------	16.35
747	756	16.22	15.74	16.79	16.25
772	779	16.17	16.95	15.19	16.10
785	4342	15.89	14.48	14.16	14.84
804	809	15.18	15.44	15.07	15.23
4621	814	15.07	15.82	15.35	15.41
829	840	16.34	16.18	------	16.26
871	887	14.77	14.17	------	14.47
901	905	16.52	15.70	------	16.11
933	937	16.51	15.95	------	16.23
946	949	15.37	16.19		15.78
Mean.		------	------	------	*15.58

* Weighted mean depending on the probable errors of observation and declination.

Summary of results—Continued.

KAHUKU. $\varphi=21° 43'.1$.

Star numbers.		Values from single observations.					Means.
		"	"	"	"	"	"
348	350	5.21	4.62	5.12	------	------	4.98
354	365	5.62	5.51	------	------	------	5.56
382	386	4.12	7.23	5.85	------	------	5.73
397	407	5.80	5.84	5.17	6.05	6.65	5.90
429	444	7.11	7.49	6.71	------	------	7.10
451	462	5.02	3.55	------	------	------	4.28
474	477	7.89	5.97	6.16	------	------	6.67
484	496	7.63	6.94	6.90	------	------	7.16
501	509	5.50	7.27	7.56	7.61	------	6.99
515	519	6.12	6.67	6.29	6.63	------	6.43
524	534	6.53	6.13	6.13	------	------	6.26
541	558	4.35	3.77	5.17	------	------	4.43
541	561	5.33	6.28	5.87	------	------	5.83
567	573	4.45	6.39	5.62	------	------	5.49
602	604	6.12	7.22	------	------	------	6.67
616	621	5.18	5.51	5.56	------	------	5.42
634	647	6.81	6.82	7.50	------	------	7.04
652	654	6.07	7.37	------	------	------	6.72
677	689	6.82	7.17	------	------	------	7.00
699	3531	7.31	6.66	------	------	------	6.99
707	725	6.36	6.29	------	------	------	6.32
742	745	5.67	6.63	------	------	------	6.15
752	755	8.48	7.18	------	------	------	7.83
765	773	5.42	6.16	------	------	------	5.79
808	815	7.19	6.36	6.62	------	------	6.72
866	873	5.14	5.08	------	------	------	5.11
5225	884	5.39	------	------	------	------	5.39
901	905	7.35	7.70	------	------	------	7.52
912	917	5.34	6.33	------	------	------	5.83
921	924	5.65	5.51	------	------	------	5.58
945	947	5.95	------	------	------	------	5.95
961	965	6.87	6.16	------	------	------	6.52
973	985	3.35	5.68	------	------	------	4.52
1022	1023	4.97	4.41	------	------	------	4.69
1045	1055	6.49	4.45	------	------	------	5.47
1065	1072	6.17	------	------	------	------	6.17
Mean.		------	------	------	------	------	6.07

[illegible]

[illegible]

[illegible]		[illegible]						[illegible]
		"	"	"	"	"	"	"
[illegible]	[illegible]	[illegible]	[illegible]				.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		..	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			..	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			1.16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		..	1.11
[illegible]	[illegible]	[illegible]	[illegible]		.		..	1.63
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.	0.33
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		......	0.85
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		..	0.94
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		..	59.86
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		....	1.09
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	.....	59.95
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		...	.....	59.65
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	...	......	0.95
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	...	......	1.07
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......	......	0.57
Mean						...	......	0.81

Summary of results—Continued.

KOLOA. $\varphi = 21° 52'.2$

Star numbers.		Values from single observations.					Means.
		″	″	″	″	″	″
575	578	13.42	12.71	13.18	------	------	13.10
591	602	13.57	13.33	------	------	------	13.45
609	621	13.54	12.17	12.82	13.19	------	12.93
616	621	14.79	15.36	15.62	14.18	------	14.99
628	2893	12.58	14.61	12.56	------	------	13.25
639	640	13.35	13.27	12.61	12.65	12.72	12.92
3131	659	12.61	12.73	12.55	13.53	------	12.86
689	696	15.36	14.44	15.13	15.10	------	14.98
705	719	13.58	12.83	11.87	------	------	12.76
726	730	11.64	14.08	13.10	12.75	13.56	13.03
733	737	12.21	11.34	12.32	------	------	11.95
742	745	14.94	14.20	13.52	16.16	------	14.71
755	764	12.79	12.03	11.61	13.80	------	12.56
4100	769	14.18	14.60	------	------	------	14.39
4143	774	12.89	11.65	12.95	12.32	------	12.46
783	4335	12.65	12.14	11.94	12.28	------	12.25
*2860	797	12.81	12.61	12.80	13.12	------	12.84
795	797	13.54	12.71	12.90	13.06	------	13.05
808	815	13.74	13.84	13.96	------	------	13.85
819	825	12.25	11.78	12.02	11.63	------	11.92
4786	835	12.51	12.59	12.93	------	------	12.68
839	4913	13.95	12.85	------	------	------	13.40
839	4920	13.43	12.99	13.23	------	------	13.22
854	860	14.17	12.66	14.16	13.28	------	13.57
866	873	15.18	14.29	14.23	14.32	------	14.50
5225	884	12.95	12.77	13.91	------	------	13.21
887	896	12.67	12.15	12.36	------	------	12.39
900	903	11.86	12.20	12.35	------	------	12.14
906	911	12.27	13.13	12.88	------	------	12.76
921	924	13.03	12.93	15.71	------	------	13.89
927	5827	12.07	13.15	13.14	------	------	12.79
Mean.		------	------	------	------	------	13.17

* B. A. C.

Summary of results—Continued.

HANALEI. $\varphi = 22^{\circ}\ 12'.9$

Star numbers.		Values from single observations.					Means.
		″	″	″	″	″	″
673	3294	56.11	56.86	56.20	------	------	56.39
704	3653	56.98	57.08	------	------	------	57.03
726	743	56.93	55.92	56.86	------	------	56.57
751	4018	56.24	56.33	54.85	------	------	55.81
766	768	55.38	55.82	56.40	------	------	55.87
770	4159	55.44	57.95	57.13	------	------	56.84
774	4240	57.92	56.90	56.03	------	------	56.95
801	820	57.61	56.65	------	------	------	57.13
805	820	57.80	55.93	56.35	------	------	56.69
828	4786	57.27	57.03	------	------	------	57.15
836	837	57.31	55.86	56.05	------	------	56.41
5055	864	57.24	57.68	55.79	56.61	------	56.83
894	896	57.27	56.66	------	------	------	56.96
901	907	56.14	55.38	54.10	------	------	55.21
910	913	55.81	56.26	55.73	57.14	------	56.24
921	924	56.72	56.15	------	------	------	56.43
927	5827	57.06	57.05	57.00	------	------	57.04
947	958	56.28	54.75	56.12	54.80	------	55.49
963	964	55.64	53.27	56.40	55.34	56.08	55.35
970	973	55.89	55.39	55.36	54.47	55.17	55.26
976	978	56.91	56.14	56.43	56.21	------	56.42
983	988	56.14	55.82	56.53	56.64	56.15	56.26
994	6415	56.74	55.71	------	------	------	56.22
6415	998	56.59	57.33	56.35	------	------	56.76
1000	1002	56.35	56.07	------	------	------	56.21
1004	1017	56.64	58.17	57.96	------	------	57.59
1004	1011	56.93	56.62	------	------	------	56.78
1004	1007	56.97	56.82	------	------	------	56.90
1022	1023	56.68	57.16	57.62	56.22	------	56.92
1030	1032	56.25	57.75	------	------	------	57.00
1158	1159	56.71	57.00	------	------	------	56.85
1165	1176	57.84	57.78	------	------	------	57.81
7891	1203	57.43	56.73	------	------	------	57.08
Mean.		------	------	------	------	------	56.51

Summary of results—Continued.

HONOLULU. $\varphi=21° 18'.0$

Star numbers.		Values from single observations.				Means.
		"	"	"	"	"
735	742	2.58	3.65	2.16	2.39	2.70
747	756	3.53	2.22	2.28	------	2.68
772	779	3.50	3.07	------	------	3.28
790	793	2.09	2.43	0.72	1.87	1.78
792	793	2.12	1.19	0.55	------	1.29
795	800	3.57	3.13	2.20	2.84	2.93
804	809	2.35	2.54	2.95	2.87	2.68
811	814	1.18	2.93	2.23	3.53	2.47
818	822	2.66	1.20	0.87	0.11	1.21
829	840	3.65	1.66	1.95	2.84	2.52
851	855	3.41	3.53	------	------	3.47
867	873	2.00	1.79	1.67	------	1.82
880	887	2.06	2.08	1.21	1.61	1.74
5336	895	2.45	1.36	2.16	2.12	2.02
901	905	2.12	2.40	1.75	1.88	2.04
919	929	3.17	2.64	1.78	3.21	2.70
933	937	3.74	3.08	3.58	3.17	3.39
946	949	3.04	3.52	------	------	3.28
955	956	2.54	2.18	2.95	------	2.55
963	971	2.88	2.20	------	------	2.54
984	991	0.78	2.29	2.19	3.15	2.10
997	6487	3.94	3.07	3.63	4.13	3.69
1004	1008	2.84	3.15	2.84	3.16	3.00
1017	1020	0.73	1.89	1.74	1.31	1.41
1032	1037	2.78	4.35(?)	3.77	------	3.63
1048	1050	1.54	0.42	0.80	1.17	0.98
1061	1072	2.43	2.73	3.61	------	2.92
1065	1072	2.09	1.94	1.80	------	1.94
1082	1086	1.96	3.01	3.36	2.77	2.78
1096	1097	2.13	2.80	4.52	------	3.15
1100	1104	1.53	1.30	1.71	1.25	1.45
1112	1121	2.77	3.61	3.14	3.25	3.19
1116	1121	2.65	2.67	1.70	1.99	2.25
Mean.		------	------	------	------	2.48

Summary of results—Continued.

KOHALA. $\varphi = 20° 15'.5$

Star numbers.		Values from single observations.			Means.
		"	"	"	"
4159	781	28.40	28.64	------	28.52
781	4298	29.30	29.78	------	29.54
793	803	29.86	29.99	------	29.92
803	806	29.99	30.80	------	30.40
816	822	27.74	28.33	27.46	27.84
3000	822	27.57	28.78	27.21	27.85
857	5059	28.72	29.04	28.40	28.72
868	875	31.37	29.84	30.33	30.51
881	882	29.54	28.60	27.71	28.62
899	905	28.49	27.73	28.71	28.31
917	918	28.84	30.22	------	29.53
5697	927	29.67	29.28	30.79	29.91
929	932	28.63	31.05	------	29.84
5806	940	30.48	30.41	30.28	30.39
950	6021	30.02	------	------	30.02
957	965	28.52	27.94	27.94	28.13
983	985	29.33	29.83	30.23	29.80
1014	1021	29.45	30.91	31.15	30.50
1029	6756	29.61	30.21	------	29.91
6885	1054	30.10	30.23	29.26	29.86
1059	6943	28.73	27.75	29.16	28.55
1069	1072	28.21	28.33	29.02	28.52
1085	1086	30.58	28.76	29.55	29.63
1091	1099	30.70	30.32	31.69	30.90
1116	1117	28.57	27.69	------	28.13
1112	1117	28.10	27.87	------	27.99
1127	1128	29.58	31.07	------	30.32
1138	1144	28.17	28.96	------	28.56
1159	1165	29.54	30.98	------	30.26
1170	7669	27.64	28.47	28.63	28.25
1170	7678	27.54	28.74	29.23	28.50
880	5293	30.96	30.33		30.65
5345	895	28.42	27.24		27.83
Mean.					29.33

Summary of results—Continued.

HILO. $\varphi = 19° 43'.2$

Star numbers.		Values from single observations.				Means.	Star numbers.		Values from single observations.
		″	″	″	″	″			″
849	4969	10.45	12.62	------	------	11.53	1073	1076	12.08
868	875	10.34	10.19	------	------	10.26	1082	1091	10.33
879	880	11.34	10.02	------	------	10.68	1099	1109	12.97
883	885	11.08	11.93	------	------	11.50	1109	1115	11.30
893	898	11.23	11.52	11.59	------	11.45	6019	960	11.93
899	900	12.88	10.3[illegible]	11.29	------	11.49	982	985	12.30
910	924	12.31	11.19	------	------	11.75	992	1000	12.85
928	932	10.95	12.04	12.39	12.27	11.91	1130	1133	13.54
5825	940	11.54	11.34	------	------	11.44	7436	1147	12.26
947	947	11.25	------	------	------	11.25	1147	7536	12.10
6072	966	11.42	11.75	------	------	11.58	1159	1165	10.83
971	973	11.31	8.49	------	------	9.90	1170	7718	10.52
977	978	10.68	10.07	------	------	10.38	1186	1194	10.99
1005	1008	12.54	11.13	------	------	11.84	1199	1204	12.90
1014	1021	10.30	9.48	------	------	9.89	1209	1217	10.64
1014	4039	12.43	10.92	------	------	11.68	1342	1346	9.47
1025	1030	10.78	11.49	------	------	11.14	1682	1697	9.62
1033	1048	11.44	10.96	11.00	------	11.13	1724	1725	10.67
1062	1072	11.17	11.59	------	------	11.38	1744	1750	9.07
							1761	1796	12.31
							1796	1798	9.33
							1825	1829	11.67
							Mean.		11.24

Summary of results—Continued.

KA LAE. [illegible]

Star numbers.		Values from single [illegible]			Means.
6388	995	50.40	[illegible]	[illegible]	[illegible]
909	1007	50.45	[illegible]	[illegible]	[illegible]
1014	1015	50.04	[illegible]	[illegible]	[illegible]
1018	1025	50.87	......	......	[illegible]
1077	1080	51.53	......	......	[illegible]
1027	1031	51.[illegible]	[illegible]	......	[illegible]
6003	1054	52.[illegible]	[illegible]	......	[illegible]
1110	1121	53.40	[illegible]	[illegible]	[illegible]
1128	1130	[illegible]	[illegible]	[illegible]	[illegible]
1140	1158	[illegible]	[illegible]	......	[illegible]
1164	1165	[illegible]	[illegible]	[illegible]	[illegible]
1175	1177	[illegible]	[illegible]	......	[illegible]
7791	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1513	[illegible]	[illegible]	......	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1540	1555	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]
1654	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1712	1725	[illegible]	[illegible]	[illegible]	[illegible]
1765	1778	[illegible]	[illegible]	[illegible]	[illegible]
1784	1795	[illegible]	[illegible]	[illegible]	[illegible]
1815	1820	[illegible]	[illegible]	[illegible]	[illegible]
1900	11276	[illegible]	[illegible]	[illegible]	[illegible]
Mean.		[illegible]		[illegible]	[illegible]

Summary of results—Continued.

KAILUA. $\varphi=19° 38'.3$

Star numbers.		Values from single observations.		Means.
		''	''	''
1082	1091	22.71	------	22.71
1099	1109	21.11	------	21.11
1109	1115	19.34	------	19.34
1130	1133	23.05	------	23.05
7436	1147	22.80	------	22.80
1147	7536	18.94	------	18.94
1159	1165	19.30	------	19.30
1170	7718	20.70	------	20.70
1186	1194	21.42	------	21.42
1199	1204	20.54	------	20.54
1209	1217	21.68	------	21.68
1322	1333	22.00	------	22.00
1342	1346	18.49	------	18.49
1428	1429	20.19	------	20.19
1471	1474	20.18	------	20.18
1588	1598	21.74	23.41	22.58
6456	1611	20.54	20.69	20.62
1608	1611	20.69	21.01	20.85
1660	1680	18.65	------	18.65
1682	1697	20.13	------	20.13
1724	1725	21.84	------	21.84
1744	1750	22.91	------	22.91
1796	1798	19.35	------	19.35
1815	1822	20.34	------	20.34
1825	1829	22.00	------	22.00
7351	1901	20.49	------	20.49
1898	1901	20.26	------	20.26
1902	1901	20.99	------	20.99
1904	1907	21.06	21.31	21.18
1928	1936	22.49	21.11	21.80
2017	2018	19.79	20.70	20.25
2022	2043	18.45	19.58	19.02
2054	2057	18.52	19.28	18.90
2077	2089	19.53	------	19.53
2091	2095	22.03	------	22.03
Mean.		------	------	20.86

Summary of results—Continued.

HAIKU. $\varphi = 20° \ 56'.1$

Star numbers.	Values from single observations.					Means.
	"	"	"	"	"	"
1138 1140	2.91	------	------	------	------	2.91
1140 1143	3.38	------	------	------	------	3.38
1180 7771	3.19	------	------	------	------	3.19
1194 1200	1.59	------	------	------	------	1.59
1209 1218	1.26	1.78	3.05	------	------	2.03
1223 1228	0.39	4.55	2.70	------	------	2.55
8115 1234	2.18	2.47	------	------	------	2.32
8135 1234	1.67	2.24	------	------	------	1.96
1237 1239	1.78	2.35	2.28	2.42	------	2.21
1244 8261	3.92	4.20	3.55	4.30	------	3.99
1269 1275	3.84	4.92	------	------	------	4.38
8467 1301	3.39	2.12	2.46	------	------	2.66
8484 1301	3.19	2.37	2.61	------	------	2.72
8497 1301	1.37	2.67	3.13	------	------	2.39
1307 1312	2.64	1.65	1.88	1.93	------	2.02
1325 1326	2.32	0.48	1.20	1.69	------	1.42
1330 1333	1.44	3.08	------	------	------	2.26
1338 1342	1.88	4.01	2.34	2.36	------	2.65
1350 1352	2.26	3.28	3.49	2.90	------	2.98
1356 1358	4.14	------	------	------	------	4.14
1363 8999	3.66	2.24	------	------	------	2.95
1390 1398	3.86	4.74	4.15	3.59	3.57	3.98
1417 1419	0.21	0.56	2.46	2.46	1.62	1.46
1402 1408	1.51	2.84	2.51	------	------	2.29
1424 1430	2.75	2.17	1.80	------	------	2.24
1434 1442	2.23	0.59	------	------	------	1.41
1449 1450	3.07	3.73	------	------	------	3.40
1452 1464	1.22	1.06	------	------	------	1.14
Mean.	------		------	------	------	2.57

Summary of results—Continued.

PAKAOAO. $\varphi=20^\circ\ 42'.8$

Star numbers.		Values from single observations.					Means.
		″	″	″	″	″	″
1216	1219	52.68	------	------	------	------	52.68
1223	1228	49.42	------	------	------	------	49.42
8141	1238	50.57	------	------	------	------	50.57
1238	8192	52.30	------	------	------	------	52.30
1269	1275	50.00	51.60	------	------	------	50.80
1314	1318	50.63	------	------	------	------	50.63
1325	1326	49.91	49.81	------	------	------	49.86
1330	1333	51.98	51.00	52.57	------	------	51.85
1339	8838	50.57	50.93	51.50	50.62	------	50.90
1350	1352	51.42	------	------	------	------	51.42
1356	1358	51.44	------	------	------	------	51.44
1357	1358	51.64	------	------	------	------	51.64
1363	8999	51.06	51.16	50.36	51.08	------	50.91
1378	1387	51.79	51.55	51.53	51.68	50.87	51.48
1390	1398	50.02	49.37	50.32	50.66	------	50.09
1402	1408	50.44	50.75	49.97	51.31	------	50.62
1417	1419	49.14	50.39	50.64	------	------	50.05
1430	1445	52.18	51.92	52.34	51.58	------	52.00
1449	1450	49.09	51.88	52.13	------	------	51.03
1452	1464	49.90	51.15	50.64	50.18	------	50.47
1474	1492	52.90	50.55	------	------	------	51.72
1496	1498	51.47	------	------	------	------	51.47
1503	1507	51.74	52.08	------	------	------	51.91
1513	1522	51.29	53.13	------	------	------	52.21
1527	1527	49.15	------	------	------	------	49.15
1549	1551	49.20	------	------	------	------	49.20
1562	10107	50.82	51.04	------	------	------	50.93
Mean.		------	------	------	------	------	50.99

HANA. $\varphi=20^{\circ}\ 45'.7$

Star numbers.		Values from single observations.					Star numbers.		Values from single observations.
		″	″	″	″	″			″
58	67	39.81	------	------	------	39.81	1235	1241	39.97
1252	1257	39.85	------	------	------	39.85	1325	1326	38.50
1269	1275	40.03	38.54	40.02	38.23	39.21	1346	1358	39.45
8445	1283	39.84	------	------	------	39.84	1356	1358	40.78
1283	8516	38.66	39.84	39.62	------	39.37	1357	1358	41.43
1308	1312	38.81	38.18	------	------	38.50	1369	1369	40.67
1330	1333	42.09	40.45	41.38	------	41.31	1378	1387	40.18
1402	1408	39.45	39.37	------	------	39.41	1390	1398	37.65
1417	1419	37.96	37.64	------	------	37.80	1471	1486	37.83
1434	1442	37.51	39.40	------	------	38.45	1496	1498	39.61
1449	1450	39.13	39.00	------	------	39.06	1503	1507	39.16
1452	1464	35.91	37.85	------	------	36.88	1513	1522	38.91
1643	1646	39.71	39.73	------	------	39.72	1531	1537	37.71
1650	1654	36.72	37.98	------	------	37.35	1562	10107	36.89
1660	1669	38.74	37.42	------	------	38.08	10174	1575	38.04
1668	1669	38.75	------	------	------	38.75	1578	1581	39.11
1682	1684	39.50	39.84	39.08	------	39.47	1578	1582	40.59
2095	2104	38.81	------	------	------	38.81	1603	1615	38.96
1692	1697	39.14	38.32	38.74	------	38.73	1638	1639	37.58
1699	1705	39.72	38.06	------	------	38.89	1677	1680	39.50
							1715	1720	39.29
							1851	1860	38.63
							11238	1900	37.36
							1907	1912	38.27
							1944	1947	37.87
							2082	2087	39.15
							2179	2	40.43
							Mean.		38.93

Summary of results—Continued.

KAUPO. $\varphi=20° 36'.7$

Star numbers.		Values from single observations.				Means.
		"	"	"	"	"
1269	1275	40.11	41.08	41.14	------	40.77
1283	8516	39.60	40.36	40.18	------	40.05
1308	1312	43.20	41.11	40.58	39.02	40.98
1325	1326	38.46	39.77	------	------	39.11
1330	1333	39.15	41.64	{40.60 40.54	42.57 40.61}	40.85
1337	1341	42.02	42.32	41.93	42.71	42.24
1346	1358	39.47	39.10	------	------	39.28
1356	1358	40.71	39.31	------	------	40.01
1357	1358	39.50	39.03	------	------	39.26
1378	1387	40.64	39.08	39.62	------	39.78
1390	1398	41.32	41.52	40.26	40.00	40.77
1402	1408	42.36	------	------	------	42.36
1410	9344	41.47	41.50	39.37	------	40.78
1427	9445	40.85	42.34	------	------	41.60
1427	9452	41.87	41.39	------	------	41.63
1427	9463	42.15	------	------	------	42.15
1449	1450	41.89	40.86	40.38	------	41.04
1452	1464	40.86	38.16	------	------	39.51
1474	1492	40.31	42.16	43.69	41.51	41.92
1496	1498	39.87	40.04	------	------	39.95
1498	1499	40.77	39.97	39.68	------	40.14
1503	1507	41.01	40.97	39.29	41.74	40.75
1517	1517	42.52	41.41	40.22	------	41.38
1527	1527	38.54	40.43	39.58	39.75	39.58
1578	1581	38.60	39.90	------	------	39.25
1578	1582	39.59	------	------	------	39.59
1643	1646	41.24	42.86	------	------	42.05
1668	1669	44.40	41.67	-----	------	43.03
1692	1697	40.14	43.28	------	------	41.70
1699	1705	40.03	40.21	------	------	40.12
1711	1715	43.06	40.23	------	------	41.65
1758	1771	41.45	41.44	------	------	41.44
1775	1778	40.69	39.22	------	------	39.95
1783	1798	40.46	38.66	------	------	39.56
1825	1837	39.83	39.43	------	------	39.63
Mean.		------	------	------	------	40.75

Observations and reductions for Honolulu.

Observations were made on four nights, using thirty-three pairs of stars and giving one hundred and sixteen determinations. The latitude of the British transit of Venus pier, as deduced by Captain Tupman, is the result of observations on thirty-five nights with two hundred and twenty-four determinations. The methods employed were, however, essentially different. The English measured the co-latitude directly, using an alt-azimuth instrument. Captain Tupman's latitude reduced to the Government observatory gives 21° 18′ 2″.32, so that the discrepancy between the two determinations is 0″.16. The distance between the two stations is about 620 feet. In order to compare the methods, in point of view of facility of computation, economy of time in observation, or accuracy of the final result, the observations and reductions are given in full.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level.		Apparent declination.	Corrections.			φ=21° 18′
				N.	S.		Micrometer.	Level.	Ref. (Mer.).	
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
5	735	S.	20.415	35.0	40.0	17 55 43.05				
	742	N.	20.030	38.5	37.0	24 39 58.93	+ 0 12.39	−0.80	0.00	2.58
			19.435	44.5	38.5	43.08				
6			19.110	43.5	40.0	58.97	10.45	+2.18	0.00	3.65
			20.220	40.0	46.0	43.11				
7			19.900	48.0	38.5	59.01	10.30	+0.80	0.00	2.16
			19.610	41.0	48.5	43.15				
8			19.220	46.0	44.0	59.06	12.55	−1.26	0.00	2.39
6	747	N.	22.265	42.0	41.5	33 41 28.82				
	756	S.	20.675	40.0	44.5	8 56 22.44	− 0 51.16	−0.92	−0.02	3.53
			20.885	50.0	36.5	28.87				
7			19.210	38.0	49.5	22.47	53.89	+0.46	−0.02	2.22
			20.515	54.0	36.5	28.92				
8			18.930	31.5	59.5	22.51	51.00	−2.41	−0.02	2.28
6	772	S.	24.890	41.0	44.0	17 59 8.35				
	779	N.	11.475	47.5	37.5	24 22 31.93	+ 7 11.63	+1.61	+0.12	3.50
			26.690	29.5	58.5	8.40				
7			13.240	58.5	29.5	34.00	12.75	0.00	+0.12	3.07
5	790	N.	29.125	37.0	39.0	24 31 2.41				
	793	S.	7.340	39.0	37.5	18 28 24.24	−11 40.93	−0.11	−0.19	2.09
			30.105	54.5	31.0	2.48				
6			8.350	29.0	56.0	24.30	39.97	−0.80	−0.19	2.43
			30.780	51.0	37.5	2.55				
7			8.970	35.5	52.5	24.36	41.74	−0.80	−0.19	0.72
			31.420	50.5	42.0	2.62				
8			9.690	37.0	55.5	24.42	39.16	−2.30	−0.19	1.87
5	792	N.	25.900	37.5	39.0	24 27 34.57				
	793	S.	7.340	39.0	37.5	18 28 24.24	− 9 57.17	0.00	−0.17 (+0.06)	2.12
			26.915	54.5	31.0	34.64				
6			8.350	29.0	56.0	24.30	57.33	−0.80	−0.17 (+0.02)	1.19
			26.550	50.5	38.0	34.71				
7			7.970	35.5	52.5	24.36	57.81	−1.03	−0.17 (+0.03)	0.55

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	φ=21° 18′
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
	795	N.	29.050	44.0	32.0	36 48 21.37				
5	800	S.	12.320	37.0	39.0	6 5 38.07	− 8 58.29	+2.30	−0.16	3.57
			28.830	48.0	37.5	21.46				
6			12.170	36.5	49.0	38.11	56.03	−0.46	−0.16	3.13
			26.560	51.0	38.0	21.55				
7			9.905	34.5	54.5	38.14	55.87	−1.61	−0.16	2.20
			28.180	48.5	44.0	21.64				
8			11.550	40.0	52.5	38.18	55.07	−1.84	−0.16	2.84
	804	S.	29.620	37.0	39.0	13 4 57.82				
5	809	N.	10.310	46.5	29.5	29 10 17.02	+10 21.30	+3.45	+0.18	2.35
			29.425	36.5	49.5	57.87				
6			10.025	51.0	35.0	17.10	24.19	+0.69	+0.18	2.54
			28.405	40.5	48.0	57.92				
7			8.970	48.0	41.0	17.19	25.32	−0.11	+0.18	2.95
			29.040	37.5	55.0	57.98				
8			9.520	48.5	44.0	17.27	28.06	−2.99	+0.18	2.87
	811	S.	17.830	29.0	47.0	− 1 29 15.50				
5	814	N.	21.115	49.0	27.0	44 8 47.49	− 1 45.70	+0.92	−0.04	1.18
			19.330	34.0	52.0	15.48				
6			22.495	49.5	37.0	47.61	41.83	−1.26	−0.04	2.93
			18.015	32.0	57.0	15.47				
7			21.150	50.5	38.5	47.73	40.87	−2.99	−0.04	2.23
			16.965	39.0	54.0	15.45				
8			20.130	47.0	45.5	47.85	41.83	−0.80	−0.04	3.53
	818	N.	33.490	34.0	32.0	31 00 20.10				
5	822	S.	7.780	37.0	29.5	12 3 15.79	−13 47.22	+2.18	−0.24	2.66
			32.930	44.0	42.5	20.19				
6			7.290	39.0	47.5	15.85	44.97	−1.61	−0.24	1.20
			33.400	51.0	38.0	20.28				
7			7.740	35.0	54.0	15.91	45.61	−1.38	−0.24	0.87
			32.750	59.0	34.0	20.38				
8			7.150	25.0	68.0	15.96	43.68	−4.14	−0.24	0.11
	829	S.	25.540	34.0	42.0	12 17 30.59				
5	840	N.	14.125	40.0	37.0	30 6 24.26	+ 6 7.28	−1.15	+0.10	3.65
6			25.250	39.5	47.0	30.64				
			13.935	47.5	40.0	24.37	4.06	0.00	+0.10	1.66
7			24.035	28.0	61.0	30.69				
			12.660	57.5	32.0	24.48	5.99	−1.72	+0.10	1.95
8			22.570	40.0	53.0	30.76				
			11.120	46.0	47.5	24.58	8.40	−3.33	+0.10	2.84
	851	S.	35.285	38.5	38.5	15 24 26.39				
5	855	N.	5.795	41.0	37.0	26 40 0.25	+15 48.94	+0.92	+0.23	3.41
6			33.575	43.0	44.5	26.50				
			4.020	42.5	45.5	0.36	50.93	−1.03	+0.23	3.56

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	φ=21° 18′
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
5	867	S.	43.810	43.0	35.0	10 12 39.01				
	873	N.	3.380	39.5	38.5	31 39 58.44	+21 40.83	+2.07	+0.38	2.00
7			42.535	34.0	55.5	39.13				
			2.070	57.0	33.0	58.64	41.96	+0.57	+0.38	1.79
8			42.500	46.0	49.0	39.19				
			2.020	48.5	46.0	58.73	42.44	−0.11	+0.38	1.67
5	880	N.	18.920	41.5	36.5	40 16 19.02				
	887	S.	20.325	36.5	41.5	2 18 14.72	+ 0 45.20	0.00	−0.01	2.06
6			20.080	42.5	46.0	19.17				
			21.540	42.0	46.5	14.75	46.97	−1.84	−0.01	2.08
7			18.070	47.0	43.0	19.32				
			19.450	42.5	47.5	14.78	44.40	−0.23	−0.01	1.21
8			18.100	53.0	41.5	19.48				
			19.575	35.0	59.5	14.82	47.46	−2.99	−0.01	1.61
5	5336	S.	15.320	35.0	44.0	− 7 34 38.64				
	895	N.	25.060	42.5	35.5	50 21 11.44	− 5 13.38	0.46	−0.11	2.45
6			15.160	39.0	49.5	38.65				
			24.865	43.5	45.0	11.63	12.26	−2.76	−0.11	1.36
7			14.510	42.5	47.5	38.66				
			24.200	42.0	48.0	11.82	11.78	−2.53	−0.11	2.16
8	5336	S.	15.535	42.0	52.5	− 7 34 38.66				
	895	N.	25.115	39.0	55.5	50 21 12.01	− 5 8.24	−6.21	−0.11	2.12
5	901	N.	32.160	50.0	29.0	32 28 40.43				
	905	S.	8.380	28.5	50.0	10 32 54.95	−12 45.12	−0.23	−0.22	2.12
6			32.235	51.0	37.5	40.57				
			8.475	36.0	52.5	55.02	44.48	−0.69	−0.22	2.40
7			31.060	54.0	36.5	40.71				
			7.405	26.0	64.5	55.09	41.10	−4.83	−0.22	1.75
8			30.225	56.0	39.0	40.86				
			6.595	26.5	68.0	55.17	40.27	−5.64	−0.22	1.88
5	919	N.	2.535	35.0	43.5	42 4 1.74				
	929	S.	35.915	39.0	40.5	− 0 3 39.49	+17 54.00	−2.30	+0.35	3.17
6			2.620	55.0	34.0	1.93				
			36.030	25.5	63.5	39.47	54.97	−3.91	+0.35	2.64
7			2.550	46.0	45.5	2.12				
			35.730	51.0	40.5	39.45	47.57	+2.53	+0.35	1.78
8			3.820	48.5	46.5	2.31				
			37.005	54.5	40.5	39.41	47.73	+3.68	+0.35	3.21
5	933	S.	20.635	31.0	48.5	9 53 6.96				
	937	N.	11.990	49.5	29.5	32 33 42.92	+ 4 38.15	+0.57	+0.08	3.74
6			21.390	34.0	55.0	7.03				
			12.730	53.5	35.5	43.10	38.63	−0.69	+0.08	3.08
7			19.170	35.5	56.0	7.10				
			10.495	54.5	37.5	43.27	39.12	−0.80	+0.08	3.58

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	$\varphi=21° 18'$
			t.	*d.*	*d.*	° ′ ″	′ ″	″	″	″
April 8			19.065	41.0	53.5	32 33 7.17				
			10.385	50.5	44.5	43.44	+ 4 39.28	−1.49	+0.08	3.17
6	946	N.	14.740	45.0	44.5	31 16 34.32				
	949	S.	25.115	42.5	47.0	11 8 25.78	+ 5 33.81	−0.92	+0.10	3.04
8			12.145	54.0	41.0	34.66				
			22.570	36.0	59.0	25.95	35.42	−2.30	+0.10	3.52
5	955	N.	14.360	46.0	33.5	43 47 27.34				
	956	S.	33.500	34.5	45.0	− 1 31 55.29	+10 15.83	+0.46	+0.20	2.54
6			13.500	50.5	39.0	27.56			(+0.03)	
			32.655	38.0	51.5	55.30	16.31	−0.46	+0.20	2.18
7			12.475	60.0	31.5	27.78				
			31.665	29.5	62.0	55.31	17.44	−0.92	+0.20	2.95
6	963	N.	15.335	50.5	38.5	39 49 5.88				
	971	S.	27.540	34.5	54.5	2 33 57.93	+ 6 32.70	−1.84	+0.12	2.88
7			15.390	58.0	34.5	6.09				
			27.620	26.5	65.0	57.97	33.50	−3.45	+0.12	2.20
5	984	N.	10.875	38.0	42.5	38 48 15.72				
	991	S.	28.860	41.0	39.0	3 28 33.29	+ 9 36.67	−0.57	+0.18	0.78
6			9.560	53.0	36.5	15.94				
			27.565	32.5	57.0	33.34	39.31	−1.84	+0.18	2.29
7			9.060	49.5	43.0	16.16				
			27.090	37.0	56.0	33.39	40.11	−2.87	+0.18	2.19
8			9.380	56.0	40.0	16.37				
			27.450	32.5	63.0	33.44	41.40	−3.33	+0.18	3.15
5	997	N.	26.505	47.0	33.5	55 24 34.65				
	6487	S.	13.850	37.0	43.5	−12 34 55.33	− 6 47.17	+1.61	−0.16	3.94
6			26.015	49.0	40.5	34.93				
			13.370	41.0	48.5	55.23	46.85	+0.23	−0.16	3.07
7			24.320	55.0	38.0	35.21				
			11.765	33.0	60.0	55.13	43.95	−2.30	−0.16	3.63
8			25.520	52.0	43.5	35.48				
			12.975	38.5	57.0	55.03	43.63	−2.30	−0.16	4.13
5	1004	N.	4.600	48.5	31.5	34 50 19.73				
	1008	S.	38.340	28.5	51.5	7 9 36.92	+18 5.58	−1.38	+0.32	2.84
6			3.855	57.5	32.0	19.94				
			37.625	27.0	62.0	36.99	6.55	−2.18	+0.32	3.15
7			4.130	52.0	41.0	20.15				
			37.965	31.0	62.5	37.06	8.64	−4.72	+0.32	2.84
8			3.170	66.0	29.5	20.36				
			37.035	17.5	78.0	37.14	9.61	−5.52	+0.32	3.16
5	1017	S.	11.785	37.5	42.0	9 4 11.23				
	1020	N.	26.590	43.0	36.5	33 47 42.30	− 7 56.35	+0.46	−0.14	0.73
6			13.710	42.0	47.0	11.31				
			28.405	42.5	46.5	42.51	52.81	−2.07	−0.14	1.89

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	φ=21° 18′
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
7			13.150	45.5	48.0	33 47 11.39				
			27.840	42.5	51.0	42.72	−7 52.65	−2.53	−0.14	1.74
8			13.075	44.0	51.5	11.48				
			27.840	50.0	45.5	42.93	55.06	0.69	−0.14	1.31
5	1032	N.	2.790	46.5	33.5	26 29 56.75				
	1037	S.	35.110	28.0	52.0	15 31 33.48	+17 19.89	−2.53	+0.30	2.78
6			3.020	52.0	37.0	56.93				
			35.320	36.0	53.0	33.60	19.25	−0.46	+0.30	4.35
7			1.230	51.5	42.0	57.11				
			33.775	22.0	71.0	33.72	27.14	−9.08	+0.30	3.77
5	1048	S.	11.195	19.0	60.0	18 24 55.35				
	1053	N.	31.635	59.0	20.5	24 33 6.56	−10 58.66	−0.57	−0.18	1.54
6			8.230	38.0	51.0	55.49				
			28.730	49.0	40.0	6.73	59.59	−0.92	−0.18	0.42
7			8.260	33.0	59.0	55.63				
			28.710	54.0	38.0	6.90	57.98	−2.30	−0.18	0.80
8			10.410	48.5	47.5	55.77				
			30.825	40.5	55.5	7.08	56.85	−3.22	−0.18	1.17
6	1061	N.	6.250	47.0	42.0	24 43 55.98				
	1072	S.	15.135	41.5	47.0	17 42 37.16	+4 45.89	0.11	+0.08	2.43
7			5.470	51.0	41.0	56.15				
			14.410	37.0	54.5	37.30	47.65	−1.72	+0.08	2.73
8			4.740	49.5	46.5	56.32				
			13.785	37.0	59.0	37.44	51.02	4.37	+0.08	3.61
6	1065	N.	31.835	44.0	44.5	25 11 24.71				
	1072	S.	15.135	41.5	47.0	17 42 37.16	8 57.32	1.38	−0.15	2.09
7			31.080	49.0	43.0	24.89				
			14.410	37.0	54.5	37.30	56.36	2.64	−0.15	1.94
8			30.425	50.5	45.5	25.06				
			13.785	37.0	59.0	37.44	55.39	−3.91	−0.15	1.80
5	1082	S.	19.475	35.5	44.5	17 11 34.62				
	1086	N.	22.320	46.0	34.5	25 27 31.29	1 31.54	+0.57	−0.02	1.96
6			17.850	40.0	49.0	34.76				
			20.550	42.0	47.0	31.47	26.87	−3.22	−0.02	3.01
7			16.490	44.0	47.0	34.90				
			19.240	43.5	47.5	31.65	28.48	−1.61	−0.02 (+0.20)	3.36
8			18.485	44.5	51.5	35.03				
			21.195	44.0	52.0	31.83	27.19	3.45	−0.02	2.77
5	1096	S.	11.565	42.5	38.0	4 0 35.21				
	1097	N.	30.380	39.0	41.5	38 55 39.25	−10 5.37	+0.46	−0.19	2.13
6			12.500	41.5	47.5	35.27				
			31.220	43.0	46.0	39.49	2.32	−2.07	−0.19	2.80
7			10.550	35.5	55.0	35.33				
			29.150	40.5	50.0	39.73	9 58.45	−4.37	−0.19	4.52

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level.		Apparent declination.	Corrections.			φ=21° 18′
				N.	S.		Micrometer.	Level.	Ref. (Mer.).	
April			t.	d.	d.	° ′ ″	′ ″	″	″	″
5	1100	N.	28.035	40.0	40.0	31 23 35.39				
	1104	S.	8.040	41.5	38.5	11 33 53.35	−10 43.34	+0.69	−0.19	1.53
6			29.260	50.5	38.5	35.60				
			9.335	34.0	54.5	53.46	41.09	−1.95	−0.19	1.30
7			30.960	43.5	47.0	35.81				
			11.075	40.5	50.0	53.57	39.80	−2.99	−0.19	1.71
8			29.205	51.0	45.0	36.03				
			9.365	34.0	62.0	53.67	38.35	−5.06	−0.19	1.25
	1112	N.	12.035	47.5	33.0	28 13 47.38	+ 3 4.68	+0.46	+0.05	2.77
5	1116	N.	24.325	47.0	34.0	28 26 58.67	− 3 30.73	+0.11	−0.05	2.55
	1121	S.	17.775	34.0	46.5	14 16 7.78				
6			12.405	54.0	34.5	47.58	+ 7.74	−1.95	+0.05	3.61
			24.730	54.5	34.5	58.87	− 28.82	−1.84	−0.05 (+0.03)	2.67
			18.240	30.0	58.0	7.90				
7			12.330	48.0	42.0	47.78	+ 8.06	−2.87	+0.05	3.14
			24.690	50.0	41.0	59.07	− 29.62	−2.18	−0.05 (+0.01)	1.70
			18.175	36.0	54.5	8.02				
8			12.750	44.5	51.5	47.97	+ 9.51	−4.37	+0.05	3.25
			25.090	45.0	51.0	59.27	− 27.53	−4.14	−0.05	1.99
			18.640	42.0	54.0	8.15				

The care taken in the preparation of the mean declinations of the stars observed seemed to warrant their publication; and, in order that they might be available for future latitude observations in the islands, their right ascensions for 1887, annual variations, precessions, etc., have been calculated and are given in the following pages.

The work was done in the Computing Division by Mr. Henry Farquhar, to whose excellent judgment in questions relating to star places the value of the list is due.

The first column gives the star number as found in the Coast and Geodetic Survey Report for 1876, Appendix No. 7. When the star does not appear in this list the number given is taken from Stone's Catalogue of 12,441 stars observed at the Cape of Good Hope. Numbers above 2179 refer to the latter list.

The catalogues consulted are indicated as follows:

Designation.	Observatory.	Conductor of observations.	Epoch.	Editor or source.
a	Edinburgh.	Henderson.	1834–'44	Smyth.
b	Do.	Smyth.	54–'69	
c	Armagh.	Robinson.	28–'54	
d	Do.	Do.	59–'82	Dreyer.
e	Radcliffe.	Johnson.	40–'54	Main.
f	Do.	Do.	54–'61	Do.
g	Do.	Main.	62+	

Designation.	Observatory.	Conductor of observations.	Epoch.	Editor or source.
h	Madras.	Jacob.	1850 ±	Smyth.
i	Greenwich.	Airy.	36-'47	
j	Do.	Do.	48-'53	
k	Do.	Do.	54-'60	
l	Do.	Do.	61-'67	
m	Do.	Do.	68-'76	
n	Glasgow.	Grant.	60-'81	
o	Bonn.	Argelander.	45-'67	
p	Washington.	----------	45-'77	Yarnall.
q	Harvard.	Rogers.	70-'79	
r	Capitoline, Rome.	Respighi.	75-'77	
s	Leiden.	Kaiser.	64-'70	
t	Pulkowa.	Struve.	45 ±	
u	Do.	Do.	65 ±	Auwers [A. G. fund. Cat.].
v	Cape.	Maclear.	34-'40	Stone.
w	Do.	Do.	49-'52	Gill.
x	Do.	Stone.	71-'79	
y	Melbourne.	Ellery.	63-'70	
z	Cordoba.	Gould.	72-'83	
+	Brussels, etc.	Quetelet, etc.	57 +	Safford.
+	Leipzig.	Engelmann.	67 ±	Auwers, Safford.
+	Harvard.	Rogers.	83-'85	
+	Ann Arbor.	Schaeberle.	79 ±	M. S.

The magnitudes are from Pickering's Photometry (Harvard Observatory Annals, vol. 14). In cases of variable stars a magnitude about the brightest attained is set down, followed by the sign +. Southern stars not in the Harvard Photometry have magnitudes taken from Gould (Z). These are of two classes, those in the "Uranometria Argentina" to tenths (here corrected by —0.2 as in Pickering), and others to quarters of a magnitude (here unaltered). Double stars not noted separately by Pickering have the *difference* taken for some other authority designated by the appropriate letter, the magnitude of the aggregate, or of the principal star, depending on Pickering, as in the other cases.

The declinations are on a system in which the proper motions of Auwers, derived from Bradley, are used, and the places of his fundamental catalogue corrected by the difference between it and that of Boss (Northern Boundary Survey Report) for 1875.

Probable errors are estimated from the number and weight of authorities used and from the time between their average epoch and 1887.

The change in one hundred years of the annual precession in declination is taken from catalogues of epoch from 1864 to 1880. It may in many cases be wrong by one to three units in the last place for 1887.

A hyphen between two letters in the list of authorities for declination denotes the use of all intervening letters.

Mean places of Hawaiian latitude stars.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
2	2.1	0 2 33	+3.1	+28 27 59.57	±0.1	−0.156	+20.052	−0.012	a, b, e, f, i–n, p–v, x, y, +
58	5.7	40 38	3.1	14 51 32.04	0.25	−0.055	19.739	0.087	a, c, d, g, l, n, +
67	6.4	43 49	3.2	27 5 42.54	0.3	−0.01	19.688	0.095	a, c, f, g, l, n, p.
	6.3	43 49	3.2	27 5 40.13	0.2	−0.01	19.688	0.095	c, f, l, n, p, r.
72	5.8	48 36	3.2	18 34 31.27	0.25	−0.015	19.604	0.104	a, c, g, l–n, +
73	5.4	0 48 55	3.2	23 0 57.55	0.2	−0.045	19.599	0.105	c, f, g, l, m, r.
255	4.7	2 51 32	3.8	39 12 35.07	0.3	-0.045	14.695	0.384	a, c, e, i, r.
264	2.7	2 56 22	3.1	3 38 42.50	0.1	−0.73	14.402	0.323	a, b, e, f, i–n, p, q, s–v, x, y, +
277	4.7	3 4 0	3.9	39 10 53.76	0.25	+0.02	13.931	0.408	a, c, e, l, m, r.
289	4.8	11 40	3.7	33 48 30.88	0.3	-0.02	13.440	0.408	a, c, l–n, r.
303	3.8	18 44	3.2	8 37 49.98	0.1	−0.068	12.974	0.363	a, c, e, f, i–n, p, q, t, u, x, +
348	5.1	42 5	3.3	10 47 41.51	0.2	−0.025	11.353	0.398	a, c, i–n, p, v.
350	5.2	42 24	3.8	32 44 38.85	0.25	0.00	11.330	0.458	a, c, l, i, r.
354	3.1	47 2	3.8	31 32 49.95	0.15	−0.002	10.992	0.462	a, d, i, j, l, m, p–r, t, u, +
365	3.6+	3 54 25	3.3	12 10 12.93	0.15	−0.009	10.447	0.417	a, c, e, f, i–m, p, q, t, u.
382	5.7	4 1 5	4.0	37 44 35.11	0.2	−0.19	9.946	0.506	a, c, f, l, m, p, r.
386	5.7	5 19	3.2	5 13 41.65	0.3	+0.01	9.622	0.410	a, c, f, l, n.
397	5.0	7 48	3.3	8 58 34.55	0.3	−0.04	9.430	0.422	a, c, l, n.
407	5.1	13 4	3.9	34 17 34.38	0.2	+0.001	9.020	0.509	a, c, l, m, r, u.
418	5.6	17 9	3.9	33 52 4.93	0.25	−0.04	8.700	0.512	a, c, l, m, p, r.
429	4.9	20 13	3.4	14 27 27.06	0.35	-0.03	8.458	0.450	a, c, l.
444	5.6	27 34	3.8	28 43 25.18	0.35	−0.04	7.870	0.505	a, e, f, j, m, n, p.
4[illegible]	5.4	31 24	3.1	0 46 6.10	0.3	−0.025	7.560	0.420	a, c, d, l, m.
462	5.3	34 53	4.2	43 8 54.82	0.3	−0.065	7.278	0.577	a, c, e, l, n, r.
471	5.2	42 18	4.0	37 17 15.87	0.25	+0.045	6.669	0.556	a, c, l, m, p, r.
474	3.3	43 42	3.3	6 45 47.65	0.25	+0.02	6.554	0.447	a, c, f, j, p, q, t, x.
477	5.0	45 4	4.0	36 30 39.87	0.2	−0.015	6.441	0.555	a, c, f, l, m, p, r, s.
478	4.0	45 11	3.2	5 24 39.79	0.15	+0.002	6.431	0.443	a, c, j, q, u, x.
484	3.9	48 22	3.1	2 15 17.26	0.15	−0.007	6.167	0.435	a, c, k, t, u, x.
496	4.0	54 35	4.2	40 54 35.70	0.15	−0.006	5.646	0.587	a, c, e, i, j, m, q, r, t, u.
501	4.7	58 7	3.4	15 14 44.93	0.25	−0.04	5.350	0.484	a, c, e, f, i, j, l, m, p.
502	3.3	4 58 35	4.2	41 4 50.12	0.1	−0.061	5.309	0.592	a, c, e, i, k–m, q–u, +
504	5.1	5 0 46	3.5	18 29 32.73	0.2	+0.02	5.126	0.496	a, c, f, j–n, p. v.
506	5.5	1 13	3.7	24 6 53.23	0.35	−0.02	5.087	0.517	a, c, i–m, p, r.
509	6.0	2 39	3.8	27 53 10.38	0.45	----	4.965	0.532	d, q.
515	4.9	5 42	4.1	38 20 58.23	0.15	−0.071	4.707	0.583	a, c, e, l, m, p–s, u, +
516	4.5	7 23	3.1	2 43 33.22	0.35	−0.01	4.564	0.447	a, l, x.
519	5.9	8 44	3.2	5 1 27.19	0.5	----	4.448	0.455	q.
524	5.0	11 12	4.2	39 59 51.15	0.2	−0.65	4.239	0.595	a, c, e, f, i, k–m, r.
534	5.0	16 54	3.2	3 26 5.45	0.2	0.00	3.749	0.453	a, i–l, n, p, q, x.
541	5.3	20 9	4.0	34 22 42.33	0.25	−0.045	3.468	0.572	a, k, m, q.
551	4.6	25 35	3.5	18 30 33.30	0.2	−0.005	2.999	0.508	a, c, i, k–m, p.
557	5.4	28 33	3.7	23 57 48.02	0.25	−0.025	2.743	0.530	a, k, m, p, r.
558	4.4	28 37	3.3	9 24 43.66	0.2	−0.002	2.737	0.477	a, c, k, q, u, x.
561	4.4	30 42	3.3	9 13 42.36	0.25	−0.305	2.557	0.477	a–c, f, i, k, x.
567	4.5	5 33 13	+3.2	+ 4 3 23.72	±0.45	+0.02	+ 2.338	−0.460	a, j.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
573	4.6	5 41 21	+4.2	+39 8 28.89	±0.2	—0.02	+1.631	—0.605	c, e, l, m, r.
575	5.3	41 56	3.2	6 24 48.78	0.3	—0.01	1.579	0.469	a, c, l, n.
578	5.2	43 20	4.1	+37 16 18.55	0.2	—0.04	1.457	0.595	a, c, l, m, p, r.
(2640)	5.3	45 55	2.9	— 7 32 57.75	0.25	—0.01	1.232	0.422	a, l, w, x, z.
591	6.0	50 1	3.7	+24 13 54.53	1.3	----	0.874	0.536	i.
600	6.0	54 2	4.7	49 54 9.11	0.4	—0.06	0.523	0.680	a, c, e, r.
602	5.1	56 46	3.6	19 41 29.30	0.25	—0.02	0.282	0.518	a, c, f, k–m, p.
604	4.3	5 57 15	3.6	23 16 6.25	0.15	— 0.105	+0.241	0.532	a, f, i–n, p, r, v.
509	4.4	6 1 7	3.4	14 46 51.97	0.15	—0.013	—0.098	0.500	a, c, f, i, k–n, p, q, u, x, +
615	5.6	5 20	3.6	19 48 52.56	0.3	—0.015	0.467	0.519	a, i, m, n.
616	4.2	5 31	3.4	14 14 0.43	0.3	—0.025	0.482	0.497	a, c, l, m.
620	3.5+	8 3	3.6	22 32 19.11	0.1	—0.003	0.704	0.528	a, c, e, f, i–n, p–r, t, u, x, +
621	4.5	8 11	3.8	+29 32 18.94	0.25	—0.265	0.715	0.558	a, c, e, f, i–m, p, r.
(2893)	6.9 z	12 43	2.4	—26 53 33.18	0.35	----	1.113	0.348	o, p, x, z.
628	5.9	15 21	6.9	+70 35 41.20	1.2	----	1.342	1.00	e.
630	3.2	16 7	3.6	22 34 14.42	0.1	—0.101	1.409	0.527	a, c, e, f, i–n, p–r, t, u, x, y, +
634	5.2	21 26	3.1	0 21 58.83	0.3	0.00	1.872	0.447	a, c, l, n.
637	4.0	22 15	3.6	20 16 57.97	0.15	—0.01	1.944	0.517	a, c, f, i–m, p, q, x.
639	6.0	25 5	3.9	32 32 3.01	0.35	—0.03	2.190	0.568	a, c, i, l–n, p.
640	4.9	25 30	3.3	11 37 18.72	0.35	----	2.227	0.484	d, n, q.
647	5.2	31 16	4.3	+42 35 13.24	0.25	—0.065	2.727	0.619	a, c–e, l, m, r.
(3131)	5.8	34 54	2.5	—23 35 37.43	0.35	----	3.042	0.358	p, x, z.
652	5.0	35 50	3.5	+17 45 18.02	0.3	—0.085	3.122	0.503	a, c, i, l–n.
654	3.2	36 59	3.7	25 14 31.34	0.15	—0.005	3.221	0.531	a, c, e, f, i–m, p–r, t, u, +
659	4.9	39 10	6.3	67 41 41.99	0.25	+0.02	3.411	0.904	a, c, e, i, j, m, p.
662	5.6	40 23	3.3	8 42 22.24	0.3	+0.01	3.515	0.469	a, c, l, n.
672	3.7	45 20	4.0	34 5 47.43	0.15	—0.032	3.942	0.565	a, c, i, j, m, p–u, +
673	4.5	47 29	5.2	+58 34 10.26	0.1	—0.123	4.126	0.743	a, c, e, f, i, l, m, q–s, u, +
(3294)	5.2	50 56	2.7	—13 53 52.72	0.2	+0.005	4.420	0.389	a, j–m, w, x, z.
677	5.9	6 53 46	3.5	+16 14 3.76	0.3	+0.01	4.662	0.488	a, c, l, n.
686	5.6	7 1 53	3.4	16 6 37.29	0.25	—0.10	5.348	0.482	a, c, k, m.
689	5.5	4 23	3.7	27 2 28.70	0.25	—0.04	5.560	0.521	a, c, i, l–n, r.
696	5.4	6 53	3.4	16 20 59.55	0.3	—0.035	5.769	0.479	a, c, e, f, i–n, p, x.
699	4.8	9 57	4.6	+49 39 53.50	0.7	----	6.025	0.636	b–e, h.
(3531)	6.6 z	12 1	2.9	— 6 28 43.21	0.35	----	6.199	0.403	x, z.
704	{6.4 e	13 37	4.9	+55 29 44.86	0.45	—0.04	6.332	0.679	c, e, l, m.
	{5.6 e	13 39	4.9	55 29 35.12	0.15	—0.028	6.333	0.679	c, e, l, m, q, r, u, +
705	5.3	14 30	4.0	36 58 19.41	0.02	—0.02	6.403	0.555	a, c, e, l, m, p, r, s.
706	5.0	15 17	3.6	20 39 21.89	0.25	—0.015	6.470	0.488	a, c, l–n, r.
707	5.3	16 19	4.2	40 53 20.36	0.25	—0.005	6.555	0.572	a, c, e, m, q, r.
715	6.3	21 2	3.6	21 40 32.03	0.2	— 0.105	6.943	0.486	a, c, i, k–n, p, r.
719	5.3	21 57	3.2	+ 7 10 17.50	0.3	—0.03	7.020	0.439	a, g, l, n.
(3653)	5.8	22 33	2.8	—11 19 42.10	0.35	0.00	7.068	0.382	f, p, w, x, z.
725	5.1	26 14	3.1	+ 2 9 11.68	0.3	+0.01	7.368	0.421	a, c, g, l, n.
726	5.0	7 27 10	+3.4	+16 4 7.70	±0.25	—0.015	—7.444	+0.462	a, c, e, i–n, p.

Mean places of Hawaiian latitude stars—Continued.

No.C.S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
729	5.8	7 28 20	+4.4	+46 25 41.89	±0.45	----	-7.539	-0.591	b, c, c, h, r.
730	4.2	28 58	3.7	+27 8 45.52	0.2	-0.105	7.590	0.498	a, c, e, f, i, k–m, p, r.
(3745)	5.1	31 40	3.0	− 3 51 33.67	0.25	+0.031	7.809	0.399	c, l, n, w, x, z.
733	6.0	32 38	4.1	+38 36 7.61	0.7	----	7.887	0.545	e, p.
735	5.2	32 57	3.5	17 55 51.63	0.3	+0.01	7.913	0.463	a, c, i, l, m, p.
737	0.5	33 23	3.1	5 30 50.14*	0.1	1.027*	7.948	0.424	a–c, e, f, i–n, p, q, s–w, x, y, +
742	3.6	37 38	3.6	24 40 4.98	0.15	-0.055	8.286	0.480	a, c, e, f, i–m, p, r, t, u, +
745	5.1	39 35	3.5	18 47 6.20	0.25	-0.04	8.443	0.459	a, c, e, i, k–m, p.
747	5.4	40 13	3.9	33 41 31.77	0.2	-0.006	8.492	0.510	a, c, l, m, p–r, u, +
751	5.8	46 29	4.4	47 51 23.06	0.2	-0.020	8.985	0.570	c, e, i, j, q, r, u.
752	4.9	46 35	3.7	27 3 26.74	0.2	-0.025	8.993	0.477	a, c, e, f, i–k, m, p–r, v.
755	5.9	50 35	3.4	16 5 29.10	0.25	—0.035	9.305	0.438	a, c, i, k–m, p.
756	6.2	51 8	3.3	+ 8 56 34.02	0.5	—0.01	9.348	0.418	c, g, n.
(4018)	5.1	54 5	3.0	− 3 22 19.87	0.2	+0.01	9.575	0.381	c, l, n, w–z.
764	5.0	56 35	3.7	+28 6 37.26	0.15	—0.039	9.766	0.468	a, c, f, i–n, q, r, u, v, x, y, +
765	5.1	58 47	3.4	13 26 21.49	0.25	—0.07	9.935	0.421	a, c, i, j, l, n, p.
766	6.2	59 37	3.6	+22 57 26.50	0.2	—0.01	9.997	0.448	a, c, i, l–n, p, r.
(4100)	7½z	7 59 48	2.5	−25 22 46.23	0.35	----	10.011	0.315	p, x, z.
768	5.2	8 1 7	3.5	+21 54 32.62	0.2	--0.065	10.111	0.442	a, c, k–n, p, r.
769	5.5	1 34	6.1	68 48 19.25	0.3	+0.005	10.145	0.761	a, c, e, i, k–m, p, q.
770	5.9	4 50	4.8	56 47 23.17	0.4	--0.035	10.390	0.600	a, c, e, i, p, r.
772	{ 5.1	5 44	3.4	17 59 16.69	0.2	- 0.105	10.458	0.425	a, c, e, f, i–n, p, q.
	{ 6.0	5.44	3.4	+17 59 12.07	0.25	—0.105	10.458	0.425	a, c, e, f, i–m, p.
(4159)†	4.6	5 58	2.8	−12 35 32.52	0.3	+0.015	10.475	0.346	a, c, g, l, w, x.
773	5.6	6 9	3.7	+29 59 39.85	0.25	--0.01	10.489	0.461	a, c, i, m, r, v.
774	5.4	8 27	5.0	+59 54 58.45	0.2	0.00	10.659	0.620	a, c, e, i, m, n, r.
(4240)	6.6z	12 12	2.8	−15 56 8.37	0.25	+0.01	10.937	0.332	a, c, l, w, x, z.
779	5.7	13 49	3.6	+24 22 37.99	0.25	—0.04	11.055	0.432	a, c, i–n, p, v.
781	5.8	15 15	4.6	+53 34 57.95	0.35	—0.095	11.160	0.554	a, c, e, i, k, r.
(4298)	6.5z	17 28	2.8	−12 41 31.17	0.25	—0.025	11.320	0.335	a, c, l, w, x, z.
783	5.8	19 6	5.8	+67 40 4.18	0.3	—0.005	11.438	0.689	c, e, k, m.
785	6.2	19 43	4.2	+46 1 58.36	0.5	—0.38	11.482	0.500	e, f, o.
(4335)	5.5	20 11	2.6	−23 40 49.38	0.35	0.00	11.515	0.305	p, v–x, z.
(4342)	6.0z	20 49	3.0	− 3 36 59.47	0.2	—0.05	11.560	0.353	a, c, g, l, n, w, x, z.
790	5.9	21 55	3.6	+24 31 8.47	0.3	—0.065	11.639	0.420	a, c, j, m.
792	5.8	24 50	3.6	24 27 40.63	0.2	—0.065	11.845	0.416	a, c, f, j–n, p, r, x.
793	5.8	25 9	3.4	18 28 32.33	0.25	-0.06	11.869	0.400	a, c, e, i–n, p, v.
	6.1	26 7	3.9	36 49 7.73	0.25	+0.005	11.937	0.451	c, i, m, r.
795	5.7	27 28	3.9	36 48 23.26	0.3	—0.03	12.031	0.449	c, i, m.
797	{ 6.1p	29 51	3.2	7 0 49.09	0.35	—0.14	12.197	0.367	a, c, n, p.
	{ 7.1p	29 51	3.2	7 0 58.12	0.4	—0.14	12.198	9.367	n, p.
800	4.1	31 40	3.2	6 5 50.20	0.25	0.00	12.324	0.362	a, c, i, j, p, q, x.
801	4.4	32 51	3.1	3 44 14.85	0.3	—0.02	12.405	0.355	a, c, k, n, x.
803	4.8	36 45	3.5	21 52 27.16	0.2	-0.035	12.671	9.390	a, c, f, i–n, p–r, v, x.
805	5.6	8 36 59	+3.3	+13 5 7.47	±0.25	—0.005	−12.686	—0.370	a, c, k–n.

* Proper motion variable; apply special correction given in "Jahrbuch" or "Ephemeris."

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
805	4.2	8 37 19	+3.1	+ 3 48 13.34	±0.35	+0.005	−12.709	−0.349	a, c, k, x.
806	4.3	38 16	3.4	18 34 8.62	0.15	−0.226	12.774	0.380	a, c, e, f, i–m, p, q, t–v, +
808	5.5	38 37	3.3	10 29 25.18	0.3	−0.01	12.797	0.362	a, c, l, n.
809	4.2	39 52	3.6	+29 10 21.32	0.15	−0.033	12.880	0.403	a, c, k–m, r, t, u, +
811	5.1	41 31	3.0	− 1 29 1.13	0.4	0.00	12.992	0.333	a, c, g, w, x, z.
814	5.2	44 22	4.1	+44 8 47.06	0.2	+0.04	13.180	0.441	a, c, e, i, k, l, p–r.
815	5.7	45 36	3.7	32 53 48.71	0.25	+0.02	13.262	0.403	a, c, l–n, r.
	6.4 f	45 41	3.6	28 40 57.70	0.25	+0.01	13.267	0.392	a, c, f, l–n.
816	6.2	45 53	3.6	28 45 42.06	0.2	−0.245	13.272	0.392	a, c, f, k, n, r.
818	5.5	47 21	3.7	31 0 23.92	0.15	−0.021	13.375	0.394	a, c, g, l, m, q, r, u.
819	5.2	48 54	3.6	28 21 28.61	0.25	−0.045	13.476	0.386	a, c, i–l, n, p, r.
820	5.8	49 11	3.9	40 38 1.31	0.4	−0.035	13.495	0.419	c, r.
822	5.7	49 45	3.3	12 3 25.81	0.2	−0.015	13.532	0.349	a, c, f, i, k–n, p.
825	5.2	50 57	3.4	15 45 19.77	0.5	+0.02	13.610	0.355	a, c, i.
829	4.3	52 18	3.3	12 17 40.51	0.15	−0.022	13.696	0.345	a, c, e, f, i–n, p, q, t, u, +
828	5.0	52 21	5.5	+68 4 8.35	0.15	+0.016	13.699	0.584	a, c, e, l, m, p, u.
(4786)	6.8 z	55 54	2.6	−23 42 43.85	0.35	----	13.924	0.273	p, x, z.
835	5.3	58 28	5.4	+67 19 32.98	0.25	−0.5	14.084	0.550	a, c, e, i–k, m, q.
836	4.7	8 59 21	3.8	38 54 12.12	0.3	−0.005	14.139	0.393	a, c, e, i, k, m, r.
837	5.6	9 0 1	3.2	5 32 35.36	0.3	0.00	14.182	0.322	a, c, g, n.
839	4.4	0 54	4.3	52 3 35.93	0.25	−0.035	14.235	0.438	a, c, e, f, k, r.
840	5.4	1 13	3.6	+30 6 28.37	0.2	+0.005	14.255	0.367	c, l–n, p, r.
(4888)	6.1	6 51	3.0	− 6 38 48.63	0.25	+0.045	14.598	0.291	a, c, l, n, w, x, z.
848	5.6	7 27	4.5	+57 12 32.61	0.25	−0.035	14.634	0.448	a, c, e, i, j, r.
849	4.9	8 3	4.4	54 29 16.28	0.25	+0.07	14.670	0.432	a, c, e, i, k, p, r.
851	5.6	9 0	3.3	+15 24 35.14	0.25	0.00	14.726	0.324	a, c, f, k–m, p.
(4913)	8 z	9 21	2.9	− 8 17 23.65	0.35	----	14.747	0.285	x, z.
(4920)	8 z	10 1	2.9	− 8 16 24.26	0.35	----	14.786	0.284	w, x, z.
854	3.4	14 10	3.7	+34 52 11.13	0.1	+0.027	15.029	0.352	a, c, f, l, m, p–u, +
(4969)	5.9	14 13	2.8	−15 21 23.16	0.35	−0.07	15.031	0.267	o, x, z.
855	4.6	18 4	3.5	+26 40 5.47	0.2	−0.035	15.253	0.328	a, c, i, k, m, r.
857	5.6	21 15	4.0	+46 5 44.95	0.25	−0.145	15.432	0.367	c, e, f, i, p, r.
(5055)	2.0	22 2	2.9	− 8 10 8.98	0.1	+0.052	15.475	0.268	a, b, e, f, i–n, p, q, s–v, x–z, +
(5059)	5.3	22 11	3.0	− 5 34 41.27	0.25	−0.075	15.484	0.271	e, k, o, x, z.
860	6.0	22 28	3.2	+ 8 40 51.14	0.3	−0.02	15.500	0.292	a, f, l, n.
864	3.2	25 18	4.0	52 11 29.83	0.1	−0.564	15.657	0.374	a–c, e, f, i–n, p–u, +
866	5.2	25 51	3.2	11 47 59.13	0.2	−0.08	15.686	0.289	a, c, e, i–n, p, x.
867	5.4	25 54	3.2	+10 12 49.17	0.25	0.00	15.688	0.287	a, c, f, i, k, l, n, p.
868	4.6	26 13	3.1	− 0 41 12.97	0.25	−0.015	15.706	0.272	a, c, g, l, w, x, z.
871	5.0	28 1	3.8	+40 7 20.85	0.4	0.00	15.805	0.334	a, c, e, r.
873	5.7	30 1	3.6	31 40 2.13	0.35	−0.075	15.910	0.313	c, g, l, n.
875	5.3	31 18	3.8	+40 44 47.66	0.25	+0.005	15.979	0.327	a, c, e, k, l, q, r,
879	4.2	34 5	3.1	− 0 37 49.26	0.2	−0.065	16.124	0.260	a, d, f, k, n, w, x, z.
(5225)	4.9	34 53	2.9	−13 49 11.29	0.25	+0.01	16.166	0.242	a, c, k, w, x, z.
880	5.5	9 35 0	+3.7	+40 16 20.19	±0.3	−0.06	−16.172	−0.319	a, c, e, l, n.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
881	3.8	9 35 7	+3.2	+10 24 21.50	±0.15	−0.018	−16.178	−0.271	a, c, e, f, i–n, p, q, t–v, x.
882	5.9	36 56	3.5	30 29 36.00	0.3	−0.10	16.272	0.296	c, f, l, m.
883	5.7	37 35	3.3	14 32 17.51	0.2	0.00	16.305	0.273	a, c, f, i, i, k, m, n, p, q, v.
884	5.6	38 31	4.3	57 38 46.91	0.2	+0.035	16.353	0.359	a, c, e, l, m, r.
885	3.1	39 26	3.4	24 17 38.76	0.1	−0.008	16.399	0.281	a–c, e, f, i–n, p–v, x, y, +
887	5.7	40 34	3.1	2 18 26.88	0.5	−0.04	16.455	0.253	c, g, n, p.
888	5.3	41 18	3.9	+46 32 49.30	0.25	−0.09	16.492	0.318	a, c, e, f, i, l, p, r.
(5293)	6.6 z	42 36	3.0	− 6 43 17.00	0.2	−0.005	16.556	0.239	c, l, n, w, x, z.
893	4.1	46 20	3.4	+26 32 19.34	0.15	-0.045	16.738	0.271	a, c, e, f, i–n, p–r, t, u, x.
894	6.0	46 23	3.1	+ 2 58 51.36	0.3	+0.11	16.741	0.244	a, c, f, k, n.
(5336)	5.3	46 55	3.0	− 7 34 24.16	0.25	-0.03	16.766	0.231	a, c, g, l, n, w, x, z.
(5345)	7.2	47 48	3.0	− 9 22 19.55	0.35	-0.04	16.809	0.228	x, z.
895	5.3	48 20	3.9	+50 21 9.94	0.25	+0.015	16.835	0.310	a, c, e, l, r.
896	5.2	50 46	3.7	41 35 35.96	0.15	-0.006	16.948	0.283	a, c, e, i, k, m, p–r, u.
898	5.3	52 9	3.2	12 59 0.31	0.25	-0.02	17.013	0.244	a, c, f, i–n, p, v.
899	5.9	53 6	3.5	30 11 9.46	0.35	-0.065	17.056	0.262	a, c, g, l, m, p, r.
900	5.0	54 15	3.2	8 35 9.75	0.15	0.011	17.109	0.236	a, c, e, f, i–n, p, q, u, v, x, +
901	6.0	9 54 30	3.5	32 28 44.08	0.2	-0.44	17.211	0.262	a, c, f, k–m, r.
903	4.6	10 0 46	3.6	35 47 42.25	0.2	+0.01	17.400	0.252	a, c, f, i–m, p, r.
905	4.6	1 54	3.2	10 33 4.55	0.25	−0.04	17.450	0.224	a, c, g, i, k–m, p.
906	4.5	2 9	3.1	0 10 49.80	0.2	+0.005	17.460	0.214	a, c, k, m, s, x.
907	1.4	2 21	3.2	12 31 9.15	0.1	+0.018	17.469	0.224	a, e–g, i–n, p–v, x, y, +
910	5.4	9 49	3.4	29 52 22.66	0.25	−0.03	17.781	0.226	a, c, f, l, n, p, r.
911	3.6	10 17	3.6	43 28 41.29	0.15	−0.058	17.799	0.240	a, c, e, i, j, l, m, p–u, +
912	5.8	10 17	3.3	24 3 51.34	0.25	+0.025	17.800	0.218	a, c, f, l, n, r.
	3.8	10 24	3.3	23 58 48.68	0.15	+0.017	17.804	0.218	a, c, k, m, n, r, t, u.
913	5.9	10 37	3.2	14 17 29.03	0.25	−0.025	17.812	0.210	a, c, e, f, j, k, m, n.
917	5.0	13 35	3.3	20 2 38.57	0.25	−0.215	17.930	0.209	a, c, f, i, n, r.
918	2.5	13 44	3.3	20 24 46.07	0.15	−0.14	17.937	0.208	a, c, e, f, i–n, p–r, t, v, x, y.
919	3.1	15 36	3.6	42 4 2.85	0.15	+0.034	18.008	0.225	a, c, e, f, i–m, q–u, +
921	5.9	16 36	3.5	34 28 41.72	0.35	−0.01	18.047	0.216	a, c, d, g, l.
924	6.2	19 18	3.2	+ 9 21 31.90	0.35	−0.04	18.149	0.191	a, c, d, g, i, k, l, n, p.
(5697)	4.1	20 38	2.9	−16 15 34.83	0.2	−0.061	18.198	0.171	a, c, f, j–m, p, q, t–x, z, +
927	4.9	23 23	3.9	+56 33 34.75	0.15	−0.032	18.298	0.227	a, c, e, f, i, k, m, p–s, u, +
928	5.2	23 44	3.1	− 2 9 39.23	0.25	−0.005	18.310	0.174	a, c, i, n, w, x, z.
929	4.9	24 31	3.1	− 0 3 27.80	0.25	−0.015	18.338	0.174	a, c, k, l, n, p, x.
932	5.1	26 38	3.5	+41 0 23.65	0.35	−0.015	18.411	0.193	a, c, e, h, k, n, p, r.
933	4.0	26 52	3.2	+ 9 53 16.35	0.15	+0.011	18.420	0.196	a, c, e, f, i–n, p, q, t–v, x, y, +
(5806)	6.1	30 45	2.8	−26 5 17.16	0.35	----	18.552	0.149	p, x, z.
(5825)	5.2	31 56	2.8	26 49 39.02	0.4	0.00	18.590	0.147	d, p, v–x, z.
(5827)	5.4	31 58	3.0	−12 47 49.42	0.5	0.00	18.592	0.154	a, d, g, h, p, w, x.
937	4.8	32 22	3.4	+32 33 46.70	0.25	+0.015	18.605	0.178	a, c, k, m, p, r.
940	5.0	34 14	4.2	66 18 28.83	0.2	-0.075	18.665	0.219	a, c, e, f, i, k–m, p.
945	5.1	37 16	3.3	23 46 46.96	0.15	+0.026	18.761	0.162	a, c, l, m, p–r, u.
946	5.4	39 35	3.4	31 16 38.19	0.15	-0.017	18.831	0.161	a, c, k–m, p–r, u, +
947	5.7	10 40 19	+3.2	+19 29 13.42	±0.35	-0.035	18.854	−0.154	a, c, f, i, q.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
949	5.3	10 43 19	+3.2	+11 8 34.53	±0.15	−0.020	−18.941	−0.144	a, c, f, g, i–n, p, q, u, v, x, y, +
950	5.7	44 17	3.8	59 55 11.41	0.2	−0.05	18.969	0.175	a, c, e, i, j, m, p, r.
955	4.9	47 28	3.5	+43 47 28.58	0.2	−0.03	19.058	0.151	a, c, e, i, k–n, q, r.
(6021)	5.2	47 58	2.9	−19 31 49.30	0.25	−0.025	19.071	0.124	a, c, f, l, o, p, v–x, z, +
956	5.9	47 59	3.1	− 1 31 43.89	0.35	+0.02	19.071	0.131	a, d, h, n, p, w, x, z.
957	5.2	49 29	3.3	+34 6 35.12	0.25	−0.05	19.112	0.142	a, c, f, k, l, n, p, r.
958	4.3	49 30	3.3	25 21 8.17	0.2	−0.005	19.112	0.138	a, c, k, m, n, p–r.
961	6.3	53 14	3.4	+36 41 59.00	0.45	−0.065	19.208	0.134	a, c, p, q.
(6072)	4.1	54 16	2.9	−17 41 49.07	0.25	+0.15	19.235	0.114	a, c, f, j, o, q, t, v–x.
963	5.4	54 30	3.4	+39 49 7.95	0.25	−0.02	19.241	0.134	a, c, e, l, r.
964	5.0	54 43	3.1	4 13 26.47	0.25	−0.01	19.245	0.119	a, c, e, f, i–n, p, x.
965	5.1	54 53	3.1	6 42 30.04	0.3	−0.03	19.249	0.120	a, c, f, i, k–n, p, v.
966	2.6	55 1	3.7	56 59 16.54	0.1	+0.041	19.250	0.142	a, c, e, f, i, j, m, p–u, +
970	4.7	10 59 11	3.1	7 56 48.59	0.15	−0.022	19.351	0.112	a, c, e, f, i–n, p, q, u, v, x, y, +
971	5.7	11 1 8	3.1	2 34 8.09	0.2	−0.07	19.396	0.107	a, c, f, g, i, k, l, n, p, q.
973	6.1	3 6	3.3	36 55 17.60	0.35	−0.065	19.438	0.112	a, c, g, l, m, p, r.
976	2.8	8 6	3.2	21 8 33.95	0.1	−0.115	19.541	0.097	a–c, e, f, i–n, p–u, x, y, +
977	3.5	9 19	3.2	16 2 49.85	0.15	−0.063	19.545	0.096	a, c, f, j, k, m, t, u.
978	4.9	9 12	3.2	23 42 40.57	0.25	−0.005	19.564	0.096	a, c, k, p, r.
983	3.8	12 23	3.3	33 42 38.88	0.15	+0.052	19.621	0.091	a, c, j, m, q, r, t, u, +
984	4.8	12 58	3.3	38 48 18.53	0.3	−0.08	19.632	0.090	a, c, e, i, k, n, r, x.
985	4.1	15 19	3.1	6 38 54.65	0.15	0.00	19.674	0.080	a, c, e, f, i–n, p, q, t–v, x, +
988	4.0	18 2	3.1	11 9 5.94	0.15	−0.063	19.718	0.075	a, c, e, f, i–h, k, m, n, p, q, t–v.
991	5.1	22 8	3.1	+ 3 28 42.80	0.2	−0.01	19.780	0.066	a, c, e, f, i–n, p, q, v, x.
(6388)	5.7	24 2	3.0	−23 50 31.51	0.35	----	19.807	0.060	o, x, z.
994	4.1	24 41	3.6	+69 57 16.58	0.15	−0.027	19.816	0.075	a, c, e, i–m, p, q, t, u, +
995	5.6	25 56	3.4	+61 42 28.99	0.3	−0.09	19.832	0.058	a, e, h, m, r.
(6415)	6.6	26 47	3.0	−26 7 26.21	0.35	----	19.843	0.055	x, z.
997	5.8	28 51	3.3	+55 24 34.43	0.4	0.00	19.869	0.050	a, c, e, h, r.
998	5.5	29 25	3.6	69 57 5.60	0.2	−0.125	19.876	0.053	a, c, e, f, k–m, p.
999	5.8	30 21	3.2	+28 24 20.16	0.25	−0.02	19.886	0.053	a, c, k, m, p, r.
1000	4.5	31 10	3.1	− 0 11 59.63	0.1	+0.047	19.895	0.049	a, c, e, f, i–n, p, q, u, v, x–z, +
1002	5.5	32 19	3.2	+44 15 5.97	0.3	−0.065	19.908	0.050	a, c, e, f, i, n, p, r.
(6487)	5.6	32 56	3.0	−12 34 47.48	0.25	+0.125	19.913	0.044	a, c, f, l, p, w, x, z.
1004	5.8	35 6	3.2	+34 50 23.70	0.2	−0.38	19.935	0.043	a, c, f, k–m, p, r.
1005	5.7	35 42	3.1	32 22 17.84	0.3	+0.02	19.941	0.042	a, c, f, l, n.
1007	4.9	39 28	3.1	8 53 10.28	0.25	−0.02	19.973	0.033	a, c, f, j–n, v.
1008	4.2	40 3	3.1	7 9 45.76	0.2	−0.17	19.977	0.032	a, c, e, f, i–n, p, v.
1011	5.2	42 7	3.1	8 52 24.13	0.3	0.00	19.992	0.028	a, c, j, k, m, n, p.
1014	5.6	43 49	3.1	35 33 33.87	0.3	−0.02	20.003	0.026	a, c, l, n, r.
1015	3.7	44 49	3.1	2 24 5.34	0.1	−0.262	20.010	0.022	a, c, e, f, i–n, p, q, s–v, x, +
1017	5.6	49 15	3.1	9 4 19.34	0.3	0.00	20.031	0.014	a, c, g, l, n.
1018	5.4	49 52	3.1	16 16 32.28	0.25	+0.01	20.034	0.013	a, l, m.
	7:	52 26	3.1	4 6 40.78	0.35	0.00	20.042	0.008	a, c, l–n.
1020	6.0	11 53 29	+3.1	+33 47 46.61	±0.45	----	−20.045	−0.005	p, q.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error. 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1021	5.2	11 54 10	+3.1	+ 4 17 4.63	±0.2	−0.01	−20.047	−0.004	a, c, e, f, i–n, p, q, v, x.
1022	4.4	55 5	3.1	7 14 39.88	0.2	−0.03	20.049	0.002	a, c, e, f, i–n, p, x.
1023	5.7	55 53	3.1	36 40 24.85	0.7	−0.09	20.050	−0.001	d, p.
1025	5.7	58 29	3.1	22 5 18.11	0.25	−0.005	20.053	+0.003	a, c, l, p, r.
1027	4.3	59 27	3.1	9 21 38.36	0.15	+0.049	20.053	0.006	a, c, e, f, i–n, p, q, t–v, x, +
1029	6.2	11 59 57	3.1	+63 33 52.20	0.35	−0.075	20.053	0.007	a, d, e, h, i, k–m.
(6756)	6.7z	12 1 14	3.1	−23 8 17.09	0.35	+0.10	20.053	0.010	p, x, z.
1030	6.3	4 46	3.1	+17 26 17.36	0.25	+0.005	20.049	0.016	c, g, l, m, +
1031	5.7	5 2	3.1	27 54 37.14	0.35	−0.04	20.048	0.017	g, l–n, p.
1032	5.9	6 7	3.1	26 29 59.31	0.25	0.03	20.046	0.019	a, c, g, j, k, m, r.
1033	5.6	6 34	3.1	21 10 16.72	0.25	−0.02	20.045	0.019	a, c, g, l, n, r.
1037	5.1	10 16	3.1	15 31 41.51	0.25	−0.02	20.033	0.027	a, c, k, m, n, +
1045	5.2	14 37	3.1	3 56 31.52	0.25	−0.06	20.013	0.036	a, c, e, f, i–k, m, p, v.
1048	4.9	15 0	3.0	+18 25 1.93	0.25	+0.075	20.011	0.036	a, c, k, m, +
(6885)	5.9	17 28	3.1	−24 12 48.18	0.2	−0.02	19.995	0.043	g, l, o, p, w, x, z.
(6903)	6.5	19 23	3.1	−27 7 21.92	0.35	.....	19.982	0.046	p, x, z.
1053	6.2	19 34	3.0	+24 33 12.43	0.25	−0.005	19.980	0.045	c, f, l–n, p, r, +
1054	6.3	19 50	2.8	64 25 43.13	0.3	−0.01	19.979	0.043	c, e, m, p.
1055	5.3	20 17	3.0	39 38 44.09	0.2	−0.026	19.974	0.046	a, c, e, i, j, n, q, r, u.
1059	5.9	23 12	2.9	56 20 18.38	0.25	−0.02	19.951	0.048	a, c, e, i, p, r, +
1061	5.5	23 48	3.0	+24 44 1.67	0.3	0.00	19.946	0.052	a, c, i, r, +
(6943)	3.1	24 1	3.1	−15 53 10.74	0.15	−1.146	19.943	0.055	a, c, e, f, j–m, p, q, u, v, x, z.
1062	5.7	24 3	3.0	+21 31 19.26	0.15	− 0.017	19.942	0.054	a, c, f, l, n, p–r, u, +
1065	5.5	25 22	3.0	25 11 30.32	0.2	−0.02	19.931	0.056	a, c, d, g, l–n, r, +
1069	4.9	29 13	3.0	23 15 6.09	0.25	+0.01	19.890	0.063	a, c, f, k–n, r, +
1072	5.6	31 18	3.0	17 42 43.70	0.25	−0.035	19.867	0.067	a, c, g, l–n.
1073	6.1	32 37	3.1	2 28 36.58	0.35	−0.015	19.850	0.070	a, c, m, n, p.
1076	6.3	33 47	2.9	+36 34 24.06	0.8	-----	19.836	0.070	a, d, p, +
1077	2.8	35 56	3.0	− 0 49 46.41	0.1	+0.015	19.807	0.077	a, c, e, f, i–n, p, q, s–v, x–z, +
1082	5.3	41 0	3.0	+17 11 42.17	0.5	+0.000	19.734	0.085	a, c, k.
1085	5.7	43 14	3.0	14 44 22.87	0.25	−0.025	19.697	0.089	a, c, g, k, l, n, p, v, +
1086	6.4	43 17	3.0	25 27 37.12	0.45	-----	19.696	0.088	d, q.
1089	5.9	44 49	2.9	38 7 54.07	0.4	0.00	19.671	0.089	a, c, e, h, i, m, p, r, +
1091	5.1	47 44	3.0	21 51 33.90	0.25	−0.03	10.620	0.096	a, c, i–k, m, r.
1096	3.7	49 55	3.0	4 0 42.42	0.15	0.047	19.579	0.104	a, c, e–g, i–n, p, e–v, x.
1097	{5.7	50 43	2.8	38 55 30.41	0.25	+0.066	19.564	0.098	e, f, h–m, p.
	{3.1	50 44	2.8	38 55 43.81	0.1	+0.066	19.564	0.098	a, c, e–g, i–n, p–u, x, y, +
1099	5.0	53 20	3.0	18 1 8.13	0.25	+0.05	19.513	0.107	a, c, k, m, q.
1100	5.1	54 52	2.9	31 23 40.76	0.2	−0.01	19.482	0.107	a, c, k–n, p, r, +
1104	3.0	12 56 33	3.0	11 34 0.09	0.15	+0.029	19.446	0.114	a, c, f, g, j–n, p, q, t, u, x, +
1109	6.1	13 0 51	2.9	21 45 35.24	0.25	−0.055	19.350	0.119	a, c, k, m, r, +
1110	6.1	0 53	2.9	23 13 22.16	0.25	−0.03	19.350	0.119	a, c, g, l, n, r, +
1112	4.9	1 45	2.9	28 13 52.61	0.25	−0.09	19.329	0.119	a, c, i, j, l, m, p, r, +
1115	4.4	4 29	2.9	18 7 38.40	0.2	+0.14	19.264	0.127	a, c, f, i, k–n, +
1116	4.4	13 6 36	+2.8	+28 27 4.16	±0.15	+0.897	−19.212	+0.128	a–c, f, i–k, m, p–r, t, u, +

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1117	5.7	13 6 55	+3.0	+12 9 24.92	±0.4	−0.075	19.206	+0.132	a, c, g, k, n, p.
1121	5.6	11 40	3.0	14 16 14.14	0.3	+0.02	19.081	0.140	a, c, g, l–n, q, +
1127	5.8	15 57	3.1	2 40 53.07	0.45	0.04	18.962	0.152	a, b, h, n, q.
1128	6.4	18 46	2.7	37 37 26.75	0.3	0.01	18.881	0.141	c, e, h, m, p, r.
1130	5.9	19 43	2.9	24 26 37.65	0.7	0.00	18.853	0.148	a, c. +
1133	5.2	22 54	2.9	+14 22 56.80	0.2	0.57	18.755	0.159	a, c, f, k–n, q, +
(7436)	6.6 z	28 19	3.4	−32 43 50.95	0.35	-----	18.583	0.193	x, z.
1138	4.9	28 24	3.0	+ 4 14 23.47	0.45	−0.01	18.581	0.172	a, c, i.
1139	3.5	28 56	3.1	− 0 1 4.04	0.15	+0.056	18.562	0.176	a, c, e, f, i–n, p, q, t–v, x, y, +
1140	5.0	29 45	2.7	+37 45 41.57	0.2	0.007	18.535	0.156	a, c, e, i, k, m, p–r, u, +
1144	5.0	32 27	2.7	36 52 11.17	0.25	0.00	18.444	0.160	a, b, h, i, j, m, p–r, +
1146	5.6	34 0	3.0	11 19 14.26	0.45	-----	18.390	0.179	a, b, d, g, h, k, n.
1147	5.6	34 28	1.4	71 49 2.72	0.2	+0.011	18.373	0.092	a, e, m, q, u.
1153	5.7	37 23	3.0	+ 4 6 37.04	0.25	0.06	18.271	0.189	a, c, f, i, k, p.
(7536)	4.4 z	39 16	3.4	−32 28 19.08	0.3	−0.15	18.201	0.216	i, k–m, p, v–z.
1158	5.8	41 28	2.8	+26 16 9.58	0.25	−0.07	18.119	0.181	a, c, i, m, p, r, +
1159	4.5	41 54	2.9	18 1 13.14	0.15	+0.040	18.103	0.188	a, c, f, g, i–m, p, u, x, +
1164	4.1	44 2	2.9	16 21 31.74	0.3	+0.045	18.022	0.192	a, c, j, m, p.
1165	5.0	44 22	2.8	21 49 31.32	0.25	+0.02	18.009	0.189	a, c, f, l, n, p, r, +
1170	4.7	48 8	1.8	65 16 53.71	0.15	−0.014	17.862	0.123	a, c, e, i, k–m, p, q, u.
1172	2.9	49 18	2.9	18 57 52.54	0.1	−0.344	17.815	0.198	a, c, e–g, i–n, p, q, s–u, x, y, +
1175	5.1	51 25	2.7	+28 2 47.33	0.2	−0.055	17.730	0.193	a, c, k–n, q, r, +
(7669)	5.1	52 11	3.4	−24 25 12.89	0.25	−0.045	17.699	9.237	g, l, p, w, x, z.
1176	5.3	53 21	2.8	+22 14 52.34	0.2	−0.05	17.650	0.201	a, c, g, l–n, r, +
(7678)	5.9	53 41	3.4	−24 27 30.32	0.25	−0.105	17.637	0.240	f, l, o, p, w, x, z.
1177	5.9	55 45	3.0	− 9.26 30.24	0.4	-----	17.549	0.216	a, d, n, q.
1180	6.2	58 48	2.2	+51 30 56.12	0.6	0.00	17.419	0.169	c, e, i.
(7718)	3.5	13 59 56	3.4	−26 8 15.01	0.25	−0.14	17 370	0.255	d–f, j, k, p, v–x, z.
1186	5.0	14 6 33	3.0	+ 2 56 29.45	0.4	−0.055	17.074	0.238	a, c, g, k, l, n.
(7771)	4.3	6 52	3.2	− 9 44 50.12	0.15	+0.141	17.059	0.251	a, c, e–g, i–m, p, q, u–x, z.
(7791)	6.5 z	9 37	3.5	−32 42 54.63	0.35	-----	16.931	0.283	p, v, x, z.
1190	5.3	9 58	1.1	+69 57 46.45	0.3	−0.07	16.914	0.093	a, e, f, h, i, k–m.
(7803)	6.5 z	11 43	3.5	−32 41 46.40	0.35	-----	16.832	0.287	p, v, x, z.
1194	4.8	13 13	2.5	+36 1 52.15	0.3	0.00	16.760	0.210	a, c, g, l, m, p, r.
1195	5.2	13 43	3.1	− 1 44 33.42	0.25	−0.07	16.736	0.254	a, c, g, l, n, v, w, z.
1198	5.9	15 9	2.5	+39 18 49.44	0.35	−0.005	16.667	0.207	a, d, e, h, l, r.
1199*	5.0	17 49	3.0	8 57 41.22	0.35	−0.005	16.536	0.249	a, c, g, n.
1200	5.0	18 34	3.0	+ 6 19 58.08	0.45	−0.03	16.498	0.254	a, c, n, p.
1202	4.9	22 23	3.1	− 1 43 15.57	0.15	−0.002	16.305	0.269	a, c, k, n, u, w, z.
(7889)	7½ z	22 33	3.5	−28 36 28.18	0.35	-----	16.299	0.303	o, p, x, z.
(7891)	5.9	22 44	3.2	− 6 23 33.76	0.2	−0.06	16.289	0.275	a, c, d, g, l, m, p, w, x, z.
1203	5.6	24 42	2.1	+50 21 2.85	0.25	−0.055	16.188	0.183	a, c, e, f, k, r, +
1204	3.6	26 58	2.6	30 52 4.19	0.15	+0.125	16.070	0.233	a, c, f, g, i–r, t, u, x, +
1209	4.5	29 46	2.6	30 14 10.64	0.25	+0.12	15.923	0.236	a, c, f, k, p, r, +
1214	6.2	14 35 14	+2.7	+22 27 36.82	±0.45	-----	−15.627	+0.255	d, q.

* Northern star.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1216	3.8	14 35 45	+2.9	+14 12 48.80	±0.15	−0.010	−15.597	+0.268	a, c, g, i–k, m, p, q, t, u, +
1217	5.0	36 6	2.9	8 38 43.90	0.45	−0.02	15.580	0.276	a, c, k.
1218	5.6	36 18	2.9	12 8 51.99	0.4	−0.12	15.568	0.271	a, c, i, n, +
1219	4.9	38 27	2.6	27 0 31.33	0.25	−0.01	15.448	0.252	a, k, m, p, r, +
1223	4.8	39 58	2.8	17 26 35.57	0.3	−0.06	15.364	0.268	a, c, k–m, p, +
1226	6.2	40 47	2.8	15 36 26.87	0.7	+0.03	15.318	0.272	a, c, +
1228	5.8	45 13	2.7	24 22 43.46	0.45	0.00	15,065	0.263	a, d, q.
1231	5.5	46 2	2.4	+37 44 9.45	0.35	+0.07	15.017	0.237	a, e, h, l, m, o, p.
(8115)	6¼ z	47 44	3.6	−32 50 19.51	0.35	0.00	14.919	0.361	p, w, x, z.
(8135)	7 z	50 26	3.6	32 22 34.59	0.4	------	14.759	0.366	a, p, x, z.
(8141)	6.9 z	50 55	+3.5	−24 59 9.85	0.35	−0.04	14.731	+0.351	d, o, p, w, x, z.
1234	2.1	51 3	−0.2	+74 37 1.99	0.1	−0.005	14.723	0.017	a, c, e, f, i–m, p, q, s–u, +
1235	5.6	51 46	+3.1	0 17 18.77	0.45	−0.01	14.681	+0.310	a, i.
1237	5.4	55 17	2.3	39 42 49.39	0.25	+0.03	14.469	0.238	a, c, e, k, m, r, +
1238	4.8	55 47	0.9	66 22 58.26	0.2	+0.059	14.438	0.102	a, e, k, m, q, u.
1239	4.6	57 11	3.0	+ 2 32 8.24	0.35	+0.01	14.353	0.314	a, c. k, n, o, v.
(8192)	3.2	57 27	3.5	−24 50 13.53	0.25	−0.033	14.336	0.362	c, e, f, i, k, l, p, w, x, z, +
1241	3.6	57 41	2.3	+40 50 12.00	0.1	−0.036	14.321	0.237	a, c, e, f, i–m, p–u, +
1242	5.6	58 36	2.4	35 38 55.10	0.8	------	14.267	0.251	a, c, i.
1244	5.8	14 58 48	1.4	+60 38 55.15	0.3	+0.02	14.253	0.149	a, e, h, o, q, r, +
(8261)	4.9	15 5 47	3.4	−19 21 48.19	0.15	0.042	13.818	0.365	a, c,e,f, i,k–m, p, q,v–x, z, +
1252	6.4	9 17	2.3	+38 41 17.70	0.35	−0.04	13.594	0.250	e, h, l, p, r.
1257	5.1	13 32	3.1	+ 2 11 35.30	0.3	−0.54	13.318	0.335	a, c, f, i, o, p.
(8367)	6.8z	16 44	3.3	−14 43 48.70	0.2	−0.015	13.108	0.373	a, c, f, g, j, k, m, p, v–x, z.
1262	5.6	16 46	1.8	+52 21 56.34	0.45	−0.01	13.106	0.200	a, b, e. h, r.
1269	5.5	20 33	2.8	15 49 34.01	0.2	+0.005	12.853	0.319	a, c, l, n, p, u.
1275	6.3	22 47	2.6	+25 29 43.52	0.4	−0.02	12.703	0.296	d, g, q, +
(8445)	7½ z	25 35	3.5	−23 29 41.36	0.4	------	12.511	0.407	p, w, x, z.
(8467)	5.3	27 46	3.6	−27 39 56.53	0.35	−0.05	12.362	0.421	d, i, j, p, v–x, z.
1283	5.9	29 21	0.8	64 35 19.90	0.3	+0.08	12.252	0.102	a, c, e, f, m, q, +
1282*	4.4	29 24	2.9	+10 55 2.24	0.35	+0.02	12.250	0.335	a, c, f, g, j, t, +
1284	2.4	29 54	2.5	+27 5 43.68	0.1	−0.094	12.214	0.297	a, e–g, i–n, p–v, x, y, +
(8484)	3.9	30 10	3.6	−27 45 36.61	0.35	−0.015	12.197	0.425	i–l, p, v–x, z.
(8497)	6.3 z	31 24	3.6	27 50 1.74	0.35	−0.03	12.111	0.427	p, w, x, z.
(8516)	5.2	33 36	3.5	−23 27 0.44	0.25	−0.04	11.956	0.419	d, f, i, k, m, p, v–x, z.
1301	6.0	37 21	0.1	+69 38 53.25	0.4	------	11.692	0.021	q, +
1307	3.8	40 58	2.8	15 46 33.91	0.15	−0.041	11.432	0.335	a, c, g, j, l, m, p, q, t, u, +
1308	5.7	42 2	2.8	14 27 49.67	0.45	−0.01	11.356	0.339	a, c, g, n, p, +
1312	4.6	44 51	2.5	26 24 52.78	0.2	−0.08	11.151	0.310	a, c, k–m, p, r, +
1314	3.7	45 11	3.0	4 49 6.30	0.15	+0.059	11.128	0.366	a, c, f, j–n, p, q, t, u, x.
1317	4.8	46 18	2.6	21 19 5.43	0.25	+0.015	11.058	0.259	a, c, k, n, p, r, +
1318	4.7	46 58	2.3	36 0 29.48	0.2	−0.37	10.996	0.280	a, c, f, k, m, p, r, +
1322	4.0	51 14	2.8	16 1 51.62	0.15	−1.286	10.684	0.343	a–c, f, g, j–n, p, q. t, u, x, +
1325	5.4	52 2	2.8	14 44 18.83	0.45	+0.06	10.624	0.347	a, g, n, p, +
1326	4.1	15 52 55	+2.5	+27 12 20.06	±0.15	−0.062	−10.558	+0.313	a, i–n, p–r, t, u, +

* Northern star.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1330	5.3	15 56 10	+2.7	+18 7 52.21	±0.25	+0.145	−10.316	+0.341	a, c, f, l–n, p, +
1333	5.0	15 57 26	2.6	23 7 7.07	0.25	+0.03	10.221	0.328	a, k, m, +
1337	5.1	16 2 58	2.7	17 20 54.95	0.2	−0.01	9.800	0.348	a, c, f, g, l–n, p, q, +
	6.3	2 59	2.7	17 21 25.48	0.3	−0.01	9.800	0.348	c, f, l, m, p, +
1338	5.2	4 50	2.2	36 46 42.49	0.2	+0.33	9.658	0.285	a, c, f, k–m, p, r, +
1339	4.2	5 12	1.9	45 13 53.54	0.2	+0.043	9.629	0.246	a, c, e–g, k, l, q, r, t, u.
1341	6.1	6 49	2.6	23 47 14.51	0.35	−0.02	9.505	0.331	a, c, i, r, +
1342	5.7	7 40	3.0	+ 5 18 38.18	0.3	−0.005	9.440	0.385	a, n, p.
(8838)	2.8	8 25	3.1	− 3 24 9.50	0.1	−0.137	9.382	0.408	a, c, e, f, i–n, p, q, s–u, x–z, +
1346	6.36	10 27	2.2	34 8 42.89	0.25	−0.08	9.225	0.297	a, c, f, g, i, m, p, r, +
	5.86	10 27	2.2	−34 8 41.68	0.35	−0.08	9.225	0.297	f, i, m, p, +
1345	5.9	10 28	2.7	+19 5 37.59	0.3	−0.09	9.223	0.347	a, g, l, n, p, +
1350	5.5	16 3	2.1	39 58 44.63	0.35	−0.025	8.787	0.274	a, e, h, n, p, r.
1352	4.8	16 21	3.0	1 17 42.40	0.35	+0.035	8.764	0.403	a, c, k.
1355	4.5	17 42	2.3	31 9 16.55	0.2	+0.10	8.656	0.312	a, c, k–n, p, r, +
1356	5.1	18 6	2.3	34 3 55.54	0.35	−0.055	8.625	0.301	a, i, k, p, r, +
1357	5.0	18 14	2.3	33 58 0.05	0.35	+0.04	8.615	0.301	a, c, d, i, k, p, r.
1358	5.7	18 40	+2.9	7 12 36.68	0.3	+0.02	8.580	+0.388	a, g, l, n.
1363	5.4	22 4	−0.2	69 22 14.35	0.5	−0.01	8.310	−0.019	a, e, h, m, +
1369	4.7	25 39	+2.6	+20 43 38.40	0.5	-----	8.024	+0.351	a, b, e, f, n–p, +
(8999)	2.9	28 51	3.7	−27 58 50.50	0.25	−0.04	7.767	0.504	c, e, f, i–m, p, q, v–z.
1378	6.1	32 36	2.8	+13 54 59.75	0.45	−0.055	7.464	0.377	c, g, n, +
1387	5.8	37 2	2.4	27 8 6.63	0.4	−0.05	7.102	0.334	c, g, k, p, +
1390	5.8	39 42	2.2	34 14 51.14	0.35	+0.065	6.884	0.306	a, g, p–r, +
1398	5.4	44 50	2.9	7 26 36.78	0.3	+0.005	6.459	0.405	a, c, k, n.
1402	4.4	48 40	2.8	10 21 7.39	0.3	−0.04	6.142	0.396	a, c, i, j, p, q, +
1408	4.0	55 58	2.3	31 5 35.93	0.15	+0.032	5.530	0.324	a, c, e–g, i–n, p–r, t, u, +
1410	6.2	57 18	1.1	56 51 16.49	0.3	+0.02	5.418	0.157	c, f, i, r, +
1417	6.0	16 59 46	2.6	19 45 21.26	0.4	0.00	5.210	0.369	a, q, +
1419	5.8	17 1 31	2.5	+22 14 15.16	0.4	−0.065	5.062	0.361	a, d, g, q, +
(9344)	2.6	3 54	3.4	−15 35 2.45	0.15	+0.097	4.860	0.488	a, c, e, f, i–m, p, q, t–x, z, +
1424	5.1	5 54	1.9	+40 55 8.14	0.4	+0.01	4.691	0.278	a, d, q, +
1427	3.3	8 28	0.2	65 51 13.89	0.15	+0.022	4.472	0.025	a, e–g, i–m, q, t, u, +
1428	3.2+	9 30	2.7	14 31 11.03	0.1	+0.030	4.383	0.391	a, b, e–g, i–n, p, q, s–v, x, y, +
1429	3.3	10 23	2.5	24 58 22.87	0.15	−0.153	4.307	0.353	a, c, f, g, j, m, p, r, u, v, +
1430	5.8	10 48	3.0	1 20 14.23	0.4	-----	4.272	0.435	a, d, q, +
1432	3.4	11 7	2.1	36 56 12.75	0.1	+0.005	4.245	0.300	a, c, j, m, n, p–u, +
1434	5.9	13 4	2.7	17 26 21.68	0.4	-----	4.078	0.382	d, q, +
1435	4.9	13 9	2.2	+33 13 20.00	0.25	−0.01	4.070	0.318	a, j, m, p, r, +
(9445)	6.6 z	14 46	3.7	−24 47 27.09	0.3	−0.04	3.933	0.527	f, k–m, p, w–z.
(9452)	3.4	15 4	3.7	24 53 8.89	0.15	−0.035	3.906	0.528	e, f, i–n, p, q, v–z, +
(9463)	6.8 z	16 13	3.7	− 24 59 15.63	0.35	0.00	3.808	0.529	f, p, w, x, z.
(1442)	5.3	16 15	2.5	+24 36 45.13	0.25	0.00	3.805	0.355	a, c, i, l–n, p, r, +
1449	5.3	19 47	2.1	37 15 4.20	0.3	0.00	3.501	0.298	f, j, m, p.
	4.5	19 47	2.1	37 15 0.84	0.2	0.00	3.501	0.298	a, f, g, j, m, p, r–t, +
1450	4.4	17 20 54	+3.0	+ 4 14 21.61	±0.2	+0.01	− 3.403	+0.429	a, c, g, i–n, p, x.

***Mean places of Hawaiian latitude stars*—Continued.**

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1452	5.2	17 23 4	+3.1	+ 0 25 21.00	±0.45	−0.03	−3.218	+0.442	a, d, i, n, +
1464	5.9	29 32	1.9	41 19 25.34	0.25	−0.08	2.657	0.277	a, e, h, k–n, r, +
1465	2.2	29 41	2.8	12 38 34.86	0.1	−0.217	2.644	0.402	a, e–g, i–n, p, q, s–v, x, y, +
1471	5.8	32 52	2.5	24 22 40.19	0.3	+0.01	2.369	0.359	a, c, i, n, p, +
1474	6.3	36 5	2.7	15 14 13.31	0.6	−0.06	2.090	0.394	d, p.
1486	5.7	42 9	2.6	17 44 21.00	0.5	−0.045	1.561	0.385	a, q, +
1492	5.4	44 14	2.4	25 39 39.47	0.2	−0.05	1.378	0.354	a, c, f, k, m, p, r, +
1496	6.2	46 52	3.0	1 20 0.15	0.35	------	1.159	0.443	n, q, +
1498	5.3	49 37	2.0	40 1 46.54	0.25	+0.055	0.907	0.285	a, c, e, l, p, r, +
1499	5.8	50 33	3.1	0 41 16.39	0.6	−0.03	0.826	0.446	g, n.
1503	4.0	52 23	2.1	37 15 57.45	0.15	+0.019	0.677	0.300	a, c, d, g, i, j, p–r, t, u.
1507	4.8	54 40	3.0	4 22 35.06	0.45	+0.01	0.466	0.434	a, j, k.
1513	6.1	56 28	2.2	33 13 4.88	0.4	−0.06	0.309	0.320	a, q, +
1517	5.1	17 57 33	2.6	20 50 2.56	0.2	+0.01	−0.214	0.374	a, c, g, k–n, r, +
1522	4.8	18 1 54	2.9	8 43 12.11	0.3	+0.02	+0.166	0.418	a, c, g, l, n.
1525	4.0	3 8	2.3	28 44 50.77	0.15	−0 01	0.274	0.341	a, c, g, i, m, p–r, t, u, +
1527	4.5	3 55	2.6	20 47 49.64	0.3	−0.03	0.344	0.374	a, c, g, l, r, +
1531	5.7	5 1	3.0	3 18 10.16	0.4	------	0.439	0.437	d, q, +
1537	5.9	9 19	2.0	38 44 32.34	0.35	0.00	0.815	0.291	d, e, h, m, p, r, +
1543	5.5	14 32	2.5	24 23 58.82	0.25	0.00	1.271	0.359	a, c, i–l, r, +
1549	5.6	16 36	2.3	29 48 19.93	0.25	+0.04	1.452	0.335	a, c, f, l, n, r, +
1551	5.9	17 20	2.8	11 58 28.03	0.4	------	1.515	0.405	q, +
1552	5.5	17 49	2.6	17 46 12.76	0.45	0.00	1.558	0.384	b, c, e, f, h, m, +
1555	5.8	20 13	2.9	7 58 9.73	0.4	------	1.766	0.419	a, d, q, +
1562	5.0	25 39	0.2	+65 29 36.28	0.3	−0.04	2.240	0.022	a, c, e, f, i, m, +
(10107)	5.9	26 59	3.7	−24 6 55.75	0.25	−0.01	2.356	0.530	g, k, l, p, w, x, z.
1571	5.8	31 48	3.1	− 0 24 14.43	0.3	−0.05	2.773	0.444	a, d, q, z, +
1573	0.2	33 7	2.0	+38 40 44.30	0.1	+0.295	2.886	0.289	a, c, e, f, i–n, p–u, x, y, +
(10174)	6.2	34 58	3.7	−23 56 15.61	0.35	−0.03	3.050	0.526	c, i, p, v–x, z.
1575	5.8	35 52	0.2	+65 23 14.20	0.2	+0.027	3.125	0.026	a, e, q, u.
1578	5.1	39 8	3.0	1 56 44.54	0.3	−0.03	3.407	0.434	a, c, g, n, p.
1581*	{ 5.0	40 36	2.0	39 33 8.45	0.15	+0.080	3.532	0.283	a, c, e, f, i, k, m, p–u, +
	6.0	40 36	2.0	39 33 11.54	0.15	+0.080	3.533	0.283	f, i, k, +
1582*	{ 5.3	40 38	2.0	39 29 42.81	0.15	+0.074	3.537	0.284	a, e, f, i, k, p, r, u.
	5.5	40 38	2.0	39 29 40.54	0.15	+0.074	3.537	0.284	a, i, k, p, r, u.
1588	4.5	42 2	2.6	18 3 23.00	0.25	+0.11	3.657	0.379	a, c, k–n, +
1589	5.7	42 36	1.9	41 19 15.77	0.4	+0.02	3.707	0.274	a, d, e, h, r.
	5.3	49 47	2.1	36 49 51.10	0.25	−0.01	4.322	0.296	a, c, g, k, l, q, r.
1602	5.7	49 57	2.9	6 28 28.94	0.25	−0.09	4.336	0.415	a, c, g, l, n, p.
1603	4.6	49 59	2.5	22 30 8.91	0.2	0.00	4.339	0.359	a, c, i, k–n, o, r, +
1608	4.5	50 33	2.1	36 45 19.97	0.3	+0.01	4.387	0.297	a, c, g, k, p, r.
1611	5.7	51 35	3.0	2 23 15.58	0.3	−0.01	4.476	0.428	a, c, i, n.
1615	6.2	53 50	2.6	19 38 28.40	0.4	------	4.667	0.368	d, q, +
1621	5.1	18 55 45	+2.3	+31 59 16.12	±0.25	0.00	+4.831	+0.318	a, c, g, l, n, p, r, +

* Southern star of pair 1581 and mean of pair 1582 usually observed.

Mean places of Hawaiian latitude stars—Continued.

No.C.S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1630	3.1	19 0 13	+2.8	+13 41 46.18	±0.1	−0.089	+ 5.208	+0.386	a–c, e–g, i–n, p, q, s–u, x, y, +
1633	5.6	1 56	2.5	24 4 33.99	0.4	0.00	5.353	0.349	a–c, f, k, +
1638	5.2	3 16	2.1	35 55 24.54	0.15	+0.009	5.466	0.298	a, c, g, l–n, p–r, u.
1639	5.3	3 28	2.9	5 53 46.56	0.3	−0.07	5.483	0.411	a, i, j, n, p.
1643	5.2	8 1	3.0	2 6 8.83	0.3	+0.01	5.864	0.420	a, c, i, j, n, p.
1646	4.5	9 55	2.0	38 57 6.98	0.25	0.00	6.022	0.282	a, c, e–g, k, m, p, r.
1650	6.2	11 1	2.3	30 19 46.30	0.35	------	6.115	0.321	d, q, +
1654	5.1	12 31	2.8	11 23 32.33	0.15	+0.025	6.239	0.388	a, c, f, g, j–n, p, q, u, x, +
1660	5.4	14 23	2.8	12 9 59.56	0.3	0.00	6.395	0.385	a, c, d, i, m, n, +
1665	5.0	18 13	2.5	26 2 45.38	0.2	−0.025	6.711	0.335	a, c, g, l–n, r, +
1668	5.3	19 35	2.9	11 42 11.48	0.2	+0.63	6.823	0.383	a–c, f, k, m, n, +
1669	4.9	19 40	2.4	29 24 2.84	0.3	+0.01	6.831	0.322	a, c, i, p, r, +
1677	6.2	22 22	2.8	14 3 16.81	0.35	0.00	7.053	0.374	a, d, n, q, +
1680	3.0	26 10	2.4	27 43 21.89	0.1	−0.020	7.363	0.325	a, c, f, g, i, j, l–n, p–u, +
1682	4.8	27 34	2.2	34 12 46.63	0.2	−0.01	7.478	0.300	a, c, g, l–n, p, +
1684	4.7	28 34	2.9	7 8 23.44	0.2	−0.14	7.558	0.391	a, c, f, i–n, p, x.
1692	6.0	31 45	2.2	36 41 39.30	0.2	0.00	7.814	0.286	a, c, g, l–n, r.
1697	5.0	33 37	3.0	5 8 27.54	0.3	0.00	7.966	0.393	a–c, i, j, n, p, x.
1699	4.9	34 55	2.4	29 53 35.77	0.25	+0.04	8.069	0.313	a, c, j, m, p, r, +
1705	5.4	37 15	2.8	11 33 41.46	0.35	+0.02	8.256	0.372	a, c, i, j, n, p, +
1711	5.8	40 10	2.9	7 20 22.94	0.25	−0.015	8.488	0.383	a, c, g, l, n.
1712	5.0	40 12	2.2	37 4 54.35	0.15	+0.042	8.490	0.282	a, c, f, k, p–r, u, +
1715	5.0	42 8	2.3	33 27 54.19	0.2	−0.45	8.643	0.296	a, c, d, f, g, k–m, r, +
1720	1.0	45 16	2.9	8 34 13.93	0.1	+0.384	8.890	0.375	a, e–g, i–n, p, q, s–v, x, y, +
1724	5.5	46 34	2.1	38 25 55.25	0.25	+0.105	8.993	0.274	a, c, e, f, h, l, p, r.
1725	3.9+	46 43	3.1	0 42 58.61	0.15	−0.003	9.003	0.395	a, c, f, j–l, n, q, t, u, x.
1737	5.7	50 41	2.2	36 41 52.43	0.35	−0.05	9.313	0.279	d, p, q, +
1742	4.7	51 49	2.1	38 11 11.68	0.25	−0.02	9.401	0.273	a, c, e, l–n, p, r, +
1744	5.3	52 38	2.7	16 29 7.56	0.3	+0.03	9.462	0.347	a, c, f, l, n.
1750	5.7	54 20	2.6	22 47 39.51	0.2	+0.02	9.594	0.327	a, k, m, n, r, +
1758	5.6	19 58 37	2.9	6 57 34.66	0.25	+0.01	9.922	0.368	a, c, i, l, n, p, q.
1761	5.4	20 0 9	2.7	19 40 4.10	0.3	+0.085	10.038	0.332	a, c, f, l, n, p, +
1765	5.3	2 2	2.6	23 17 20.72	0.2	−0.01	10.18[illegible]	0.320	a, c, i, l–n, p, r.
1771	6.2	3 22	2.3	34 5 42.89	0.35	0.00	10.280	0.283	d, p, q, +
1775	5.5	5 51	2.5	26 34 10.70	0.25	0.00	10.467	0.308	a, c, i, k, l, p, r, +
1778	5.1	9 3	2.8	14 51 14.56	0.2	+0.07	10.704	0.338	a, c, j, k, m, n, p, q, +
1783	5.0	10 18	2.2	36 27 38.40	0.25	+0.09	10.797	0.271	a, c, f, g, l, n, p, r, +
1784	4.8	10 28	2.5	25 14 49.17	0.35	−0.045	10.810	0.308	a, b, d, h, k, n, o, r, +
1795	6.5	14 11	2.8	12 51 47.64	0.45	−0.06	11.082	0.338	a, n, q.
1796	5.2	14 19	2.3	34 37 48.14	0.25	+0.01	11.090	0.276	a, c, g, l, m, r.
1798	5.4	17 35	3.0	4 58 55.61	0.5	−0.07	11.327	0.354	a–d, g, h, n, p.
1815	6.3	27 8	2.6	25 25 24.47	0.35	------	12.007	0.295	d, q, +
1820	5.2	28 36	2.8	12 38 26.88	0.25	+0.04	12.111	0.325	a, c, g, l–n, p, +
1822	4.7	30 1	2.8	14 17 5.63	0.25	0.00	12.209	0.320	a, c, f, i, k, n, p, q, +
1825	5.6	20 32 15	+2.6	+26 4 8.68	±0.25	−0.015	+12.363	+0.289	a, c, i, m, p, r.

Mean places of Hawaiian latitude stars—Continued.

No.C.S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1829	6.1	20 33 24	+2.8	+12 55 7.93	±0.25	—0.01	+12.442	+0.319	a, d, k, l, n, +
1837	4.0	34 23	2.8	15 30 50.04	0.15	—0.002	12.510	0.312	a, f, g, i–n, p, q, t, u, x, +
1851	2.7	41 38	2.4	33 32 50.45	0.1	+0.335	12.999	0.261	a, f, g, j–l, p–u, +
1855	5.2+	42 40	2.4	33 57 33.66	0.5	------	13.068	0.259	o, p, +
1860	6.1	44 16	2.9	7 56 40.21	0.3	+0.01	13.174	0.319	a, c, g, m, n, p.
1870	5.9	20 50 1	3.0	+ 4 6 5.30	0.4	0.00	13.549	0.318	a, c, g, n, p.
(11238)	4.6	21 3 26	3.3	—11 49 43.09	0.2	—0.007	14.391	0.327	a, c, e, i–m, p, w, x, z, +
1898	4.8	4 51	2.9	+ 9 40 36.44	0.2	—0.175	14.476	0.288	a, c, f, k, l, n, p, q, x.
	5.9	5 2	2.9	9 35 18.60	0.3	+0.01	14.487	0.288	c, f, m, n, p.
1900	5.7	6 46	1.9	53 6 6.73	0.2	—0.015	14.592	0.179	a, c, e, m, n, r, s, t.
1901	3.5	8 8	2.5	29 45 49.36	0.1	—0.066	14.674	0.248	a, c, e–g, i–n, p–r, t, u, x, y, +
1902	4.6	8 59	2.9	+ 9 32 58.29	0.2	—0.295	14.724	0.283	a, c, f, k, n, x.
(11276)	5.5	6 29	3.3	—15 38 25.43	0.2	0.00	14.755	0.323	a, c, e, i–m, p, x, z.
1904	4.1	10 10	3.0	+ 4 46 52.15	0.15	—0.078	14.794	0.290	a, c, i–n, p, t, u, x.
1907	4.4	13 16	2.5	34 25 21.46	0.25	—0.02	14.977	0.233	a, c, e, f, j, p, r, +
1912	6.0	15 29	3.0	6 52 32.95	0.3	—0.025	15.105	0.279	a, c, n, p.
1928	5.4	22 41	2.6	27 7 0.80	0.25	+0.02	15.512	0.238	a, c, d, f, l, m, r, +
1936	5.9	25 42	2.9	11 38 29.49	0.35	0.00	15.677	0.258	a, d, o, q, +
1044	5.1	32 25	2.4	39 54 22.00	0.15	+0.009	16.037	0.204	a, c, e, l, p–r, u, +
1947	5.4	33 49	3.0	1 44 9.47	0.3	—0.08	16.110	0.259	a, c, l, n, p.
1950	5.8	36 24	3.1	0 46 15.17	0.3	—0.025	16.244	0.256	a, c, g, l, n.
1953	5.3	21 37 50	2.4	40 33 41,48	0.3	+0.01	16.318	0.198	c, e, l, p, r, +
2017	5.1	22 15 57	3.0	11 38 9.85	0.15	+0.010	18.022	0.182	a, c, k, m, n, p, q, +
2018	4.9	16 6	2.8	27 45 41.56	0.2	0.00	18.027	0.170	a, c, i, l–n, p, r, +
2022	4.6	19 30	3.1	0 48 14.99	0.2	—0.01	18.156	0.183	a, c, f, i, k, l, n, p, q, x.
2043	6.3 e	30 50	2.7	39 2 36.23	0.35	—0.02	18.555	0.141	c. e, f, l, p, +
	5.8 e	30 51	2.7	39 2 58.59	0.3	—0.02	18.556	0.141	a, c, e–g, l, p, r, +
2054	3.6	35 50	3.0	10 14 29.89	0.1	—0.018	18.716	0.149	a–c, e–g, i–q, s–v, x, y, +
2057	3.1	37 42	2.8	29 37 49.42	0.15	—0.033	18.774	0.137	a, c, f, g, i, j, m, p–r, t, u, +
2077	6.0	49 47	2.8	36 28 28.16	0.35	------	19.120	0.115	d, q, +
2082	5.6	53 40	3.1	0 21 34.45	0.3	—0.08	19.219	0.121	a, d, f, l, n, p.
2087	3.8	56 43	2.7	41 43 7.80	0.15	0.00	19.294	0.102	a, c, e, i–k, m, p–u, +
2089	4.6	58 8	3.1	3 12 42.33	0.25	—0.015	19.327	0.111	a, c, e, f, i, k, l, p, x.
2090	2.6+	58 18	2.9	27 28 11.70	0.15	+0.133	19.330	0.105	a, c, f, i–m, p, r, t, u, +
2091	2.6	22 59 8	3.0	14 35 50.94	0.1	—0.030	19.349	0.107	a, b, f, g, i–n, p, q, s–u, x, y, +
2095	4.9	23 1 37	2.9	24 51 30.99	0.2	—0.02	19.406	0.100	a, c, k–m, p, r.
2104	6.1	5 5	3.0	16 58 58.32	0.6	+0.02	19.481	0.098	c, n, +
2179	5.8	23 59 54	+3.1	+12 46 2.07	±0.25	0.00	+20.053	+0.007	a, c, g, l–n, p, +

GRAVITY.

Descriptions of stations.

Pakaoao.—This station is situated on the edge of the crater of Haleakala, near the southwestern corner (see illustrations Nos. 39 and 42). It was connected trigonometrically with Haleakala △ point by Mr. F. S. Dodge. The distance from the △ station to the latitude pier is 71.8 feet and the azimuth 145° 12′. The pendulum-house was about 12 feet south of the latitude pier (see illustration No. 42).

The lower end of the pendulum was 24 feet below the △ point, the height of which is given by the Government Survey as 9,870 feet above mean tide. This point has since received the name of Pendulum Peak. (Am. Journal of Science, February, 1889.)

Haiku.—The pendulums were swung in the basement of the old sugar-mill on the plantation of Mr. Henry Baldwin. It is situated about 4 miles east of Paia. Around the pendulum support was built a tight wooden compartment 5 feet square and 10 feet high to prevent disturbance by currents of air. The latitude pier was situated a few feet north of the building. The connection of the latitude pier with the triangulation station at Puu o Umi was also made by Mr. Dodge, who gives the height of the bottom of the pendulum above mean tide as 385 feet.

Honolulu.—The northeast corner room of the Government building (Kapuaiwa) was chosen for the observations at this station, the pendulums being hung against the east wall from two heavy iron brackets. A weight somewhat heavier than the heaviest pendulum was placed at the extremity of the arms and no flexure which could affect the result of the observations was detected. Time was determined at the new observatory about 50 feet eastward of the building, and the signals were transmitted electrically to the chronograph, which was in the pendulum-room. Around the pendulums were placed screens to prevent rapid changes of temperature and currents of air. The bottom of the pendulum was 10 feet above mean tide.

San Francisco.—Davidson Observatory in Lafayette Park, at the corner of Clay and Octavia streets, was occupied. The pendulums were swung from a stand (see illustration No. 49) and were observed from an adjoining room. The station is 378 feet above mean tide.

Lick Observatory.—Observations were made in the cellar of the transit house. The top plank of the stand used in San Francisco was supported at one end by the east collimator pier, and at the other by a brick wall. The pendulums were 4,205 feet above mean tide.

Washington.—The pendulum-room at the Smithsonian Institution, the northeast corner of the basement, was occupied. The pendulums were swung from a stand (see illustration No. 49) similar to the one used in San Francisco. The height of the station above mean tide is 34 feet.

Methods of observation.

The plan generally followed was to swing the pendulums at each station on the same support and to continue the observations through the entire twenty-four hours. This method was adhered to as far as local circumstances would permit. A wooden stand (illustration No. 49) was used at San Francisco and Washington. A heavy plank imbedded in masonry was used at Pakaoao and the Lick Observatory, and this same plank was used at Honolulu and Haiku firmly supported on massive iron brackets which were imbedded in a stone wall. Head No. 0 was used at all the stations. At the Lick Observatory only day observations were made. The iron brackets were tested for vertical flexure. No appreciable amount was discovered. The horizontal flexure of the head is supposed to have been the same at each station. The knife-edge plane was tested for horizontality before beginning each position and also after its conclusion. Three thermometers were used, suspended near the top, middle, and bottom of the pendulum, the bottom one being attached to a rod of the same metal as the pendulum and read continuously during the swing by means of the telescope used in taking the transits. The others were read at the beginning and end of swings. The thermometers were compared immediately after the observations at each station and had their zero points determined at Honolulu, San Francisco, and Washington. The pendulums were allowed to swing for 15,000 oscillations with the heavy end down and for 5,000 in the inverted position.

Time was determined at 8 p. m. and the pendulums were started at the mean epoch of the star observations. The half amplitude of oscillation was about 50′ at the beginning and 5′ at the end.

Two barometers, mercurial and aneroid, were read as well as the wet and dry bulb thermometers. The pendulum observations were registered electrically on a Fauth chronograph (illustration No. 50). Forty transits were taken at the beginning and end of swings, with one or two intermediate ones at intervals of an hour in order to count the whole number of oscillations. The probable error of the mean of forty transits is about $0^s.003$.

The approximate value of an oscillation may be obtained at a new station by applying a correction of one one-hundred-thousandth of a second for a change of one second in the rate of the clock, 1 degree in the temperature, 1 inch in the pressure, one-hundredth of the radius in the amplitude, 100 metres in the elevation or ten minutes in the latitude (20°). But this method was checked at each station from transits near the end of a swing. The rule adopted was to take sixty transits, allow ten minutes to elapse, and take forty more. Allow thirty minutes to pass and take forty additional transits. This with the regular observations gives sufficient data for the determination of the period to the nearest ten-thousandth of a second, which is sufficiently accurate to make the count during an interval of two hours.

The chronometer correction was determined by observing ten stars each evening. Four time stars and one circumpolar were taken in each position of the instrument and transits were observed across the five middle threads of the diaphragm. Readings of the level were made before and after each set and during the observations if time served. The transits were registered electrically on the Fauth chronograph.

The observations on the pendulum and the thermometer below were made by means of a reading telescope at a distance of about 15 feet. A window of plate-glass was built in the front wall of the pendulum-house at Pakaoao, and a theodolite standing in the transit tent was used in observing.

Methods of reduction.

The corrections to the time of oscillation on account of the amplitude were calculated by Borda's formula

$$\frac{Mn}{32} \frac{\sin(\varphi + \varphi') \sin(\varphi - \varphi')}{\log \sin \varphi - \log \sin \varphi'}$$

φ and φ' being the initial and final arcs, n the number of oscillations, and M the modulus of the common system of logarithms.

In finding the periods, the use of eight-place logarithms was avoided by using the formula

$$\frac{B}{A \pm i} = \frac{B}{A}\left(1 \mp \frac{i}{A} \pm \frac{i^2}{A^2} \mp \text{etc.}\right)$$

As the entire interval was only increased by about its $\frac{1}{10000}$ part on account of the amplitude, all terms involving higher powers than the first are inappreciable in the seventh place, and $\frac{i}{A}$ can be disposed of mentally, only requiring one or two places.

The corrections for pressure and temperature depend on Peirce's co-efficients. The atmospheric effect is considered in two parts, the first varying directly as the pressure and inversely as the temperature, and the second directly as the square root of the pressure and inversely as the eighth root of the temperature. As communicated by Professor Peirce, the co-efficients for Washington in sidereal time at one absolute atmosphere (1,000,000 C. G. S. units of pressure) and 15° Centigrade are:

Pendulum.	Heavy end down.		Heavy end up.	
	First part.	Second part.	First part.	Second part.
	Seconds.	*Seconds.*	*Seconds.*	*Seconds.*
No. 3.	0.0003107	0.0000349	0.0008821	0.0001047
No. 4.	0.0003315	0.0000428	0.0009905	0.0001274

For any other station the correction is

$$\left(\sqrt{\frac{g_w}{g}} - \frac{288.1}{t+273.1} \quad \frac{\mathrm{P}}{29.554}\sqrt{\frac{g}{g_w}}\right)\mathrm{K}$$

K being the co-efficient for Washington, g_w gravity at Washington, g gravity at any other station, t the temperature Centigrade, and P the pressure in inches.

The temperature corrections used for one oscillation per degree Centigrade are:

Pendulum.	Heavy end down.	Heavy end up.
	Seconds.	*Seconds.*
No. 3.	0.00000877	0.00000878
No. 4.	0.00000921	0.00000920

Differential corrections were first applied to reduce to the mean temperature and pressure of the station. The mean period is then brought to 15° temperature and to one absolute atmosphere.

The attraction of Haleakala on the plumb-line at Kaupo (Ka Lae o Ka Ilio) was calculated by Hutton's formula

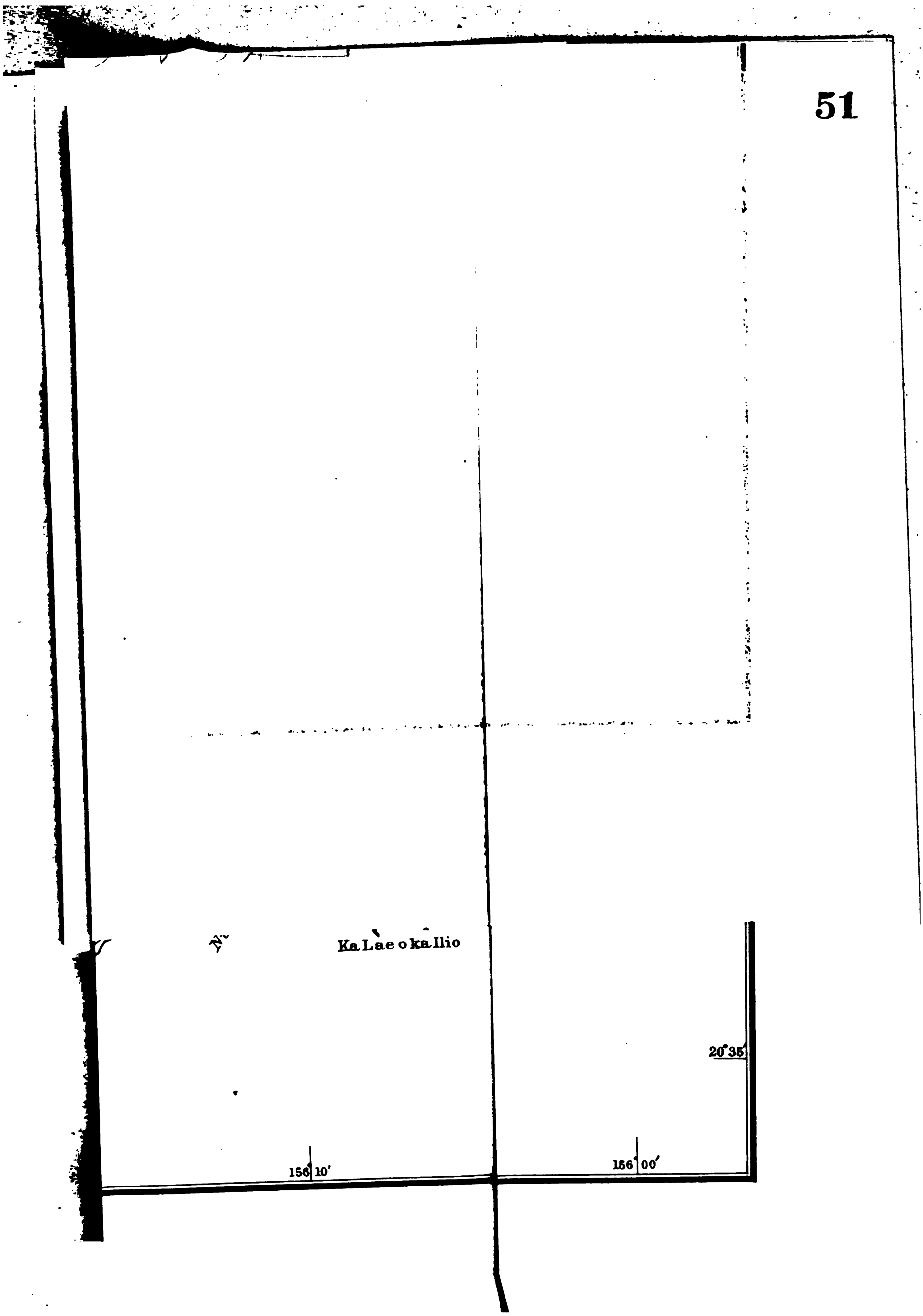
$$\mathrm{A} = \rho \int_{a_1}^{a_2} \int_{r_1}^{r_2} \int_{0}^{h} \frac{r^2 \cos a\,da_1 dr_1 dz}{(r^2+z^2)^{\frac{3}{2}}}$$

(Clarke's Geodesy, page 295) using a value for ρ derived from a comparison of the pendulum observations at the summit and at the sea.

The island of Maui is divided into compartments by radial lines and concentric circles following the usual method. In the present case the first series of circles extends to the summit. They have a common difference in the radii of 1 mile. The second series extends to the valley beyond, with radii having a ratio of $\frac{11}{10}$. The third series includes all remaining matter above the sea-level (see illustration No. 51). The sines of the angles between the radii and the meridian of Ka Lae o Ka Ilio have a common difference of one-tenth. This arrangement facilitates the computation by making the attractions vary as the heights for the compartments in any given ring. The unit of height is taken as 100 feet, and we have the following heights for East Maui:

Compartment heights.

Circle.	Sector.										Sums.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	
1- 2	1.0	4.0	4.5	7.5	9.0	9.0	9.5	10.0	10.0	10.0	74.5
2- 3	4.5	8.0	12.0	14.0	15.0	16.5	17.5	18.0	19.5	20.0	145.0
3- 4	4.5	12.5	14.5	20.0	23.0	25.0	27.5	30.0	31.5	31.0	219.5
4- 5	8.5	20.5	26.0	31.5	40.0	43.0	46.0	46.0	44.0	42.0	347.5
5- 6	13.0	30.0	38.0	48.0	57.5	65.0	68.0	61.0	54.0	53.5	488.0
6- 7	20.0	40.0	52.0	66.0	73.0	75.0	75.0	69.0	63.5	65.0	598.5
7- 8	26.5	52.0	68.0	76.5	76.0	73.5	72.5	73.0	73.0	77.5	668.5
8- 9	32.5	63.5	79.0	78.5	73.0	73.0	74.5	76.5	74.5	72.0	697.0
9-10	38.0	75.0	95.0	84.5	75.5	71.0	72.5	71.5	66.5	62.0	711.5
10-11	44.5	79.5	83.5	87.5	80.5	71.5	64.0	62.0	60.0	54.0	687.0
11-12	56.0	73.0	77.5	77.5	76.5	69.5	58.5	54.5	52.5	45.5	641.0
12-13	42.5	64.0	65.0	65.5	63.0	59.5	54.5	46.0	41.0	36.0	537.0
13-14	43.0	49.0	49.0	51.5	51.0	50.0	47.0	39.0	29.0	22.5	431.0


Ka Lae o ka Ilio
20°35′
156°10′
156°00′

Compartment heights—Continued.

Circle.	Sector.										Sums.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	
14–15	34.0	32.5	34.0	38.5	41.0	42.0	40.0	32.5	19.0	9.5	323.0
15–16	15.5	19.5	22.5	28.0	30.5	35.5	29.0	22.0	10.0	----	212.5
16–17	8.0	11.5	15.0	19.5	22.0	22.0	19.0	12.0	----	----	129.0
17–18	----	6.5	9.5	13.0	15.5	15.0	10.5	9.0	----	----	79.0
18–19	----	3.0	5.5	7.5	9.0	8.5	5.5	-----	----	----	39.0
19–20	----	1.0	3.0	3.0	3.0	1.0	----	-----	----	----	11.0

Circle.	Sector.										Sums
	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	
1– 2	10.0	9.5	9.0	9.0	8.0	6.5	5.0	3.0	1.0	----	61.0
2– 3	20.0	18.5	16.5	15.0	14.0	13.0	9.5	6.0	2.0	----	114.5
3– 4	30.5	29.5	27.0	24.0	23.0	22.0	17.0	11.0	4.0	----	188.0
4– 5	44.0	46.0	43.0	36.0	35.0	30.5	25.0	17.0	6.5	----	283.0
5– 6	59.0	62.0	56.0	49.5	42.0	34.5	28.0	20.0	10.0	----	361.0
6– 7	65.0	65.5	58.0	50.0	42.5	34.5	29.0	23.5	12.0	----	380.0
7– 8	72.5	65.5	58.0	50.5	45.0	36.0	33.5	27.0	11.0	----	399.0
8– 9	69.0	62.5	55.0	51.0	48.0	42.0	37.0	28.0	8.0	----	400.5
9–10	57.0	50.0	45.5	45.0	44.0	41.5	37.5	26.5	6.0	----	353.0
10–11	47.0	39.5	36.0	35.5	37.5	37.5	34.5	22.5	1.0	----	291.0
11–12	37.5	30.0	26.5	28.0	29.0	31.0	28.5	16.0	0.0	----	226.5
12–13	28.5	21.0	18.5	19.5	21.5	20.0	14.5	5.5	----	----	149.0
13–14	16.0	7.5	7.5	7.0	5.0	6.5	4.5	1.0	----	----	55.0
14–15	3.5	----	----	----	----	----	----	-----	----	----	3.5

We therefore have for the attraction of the compartment in sector I and between circles 1 and 2

$$A = \rho(r_2 - r_1)(\sin a_2 - \sin a_1)\frac{h}{r}$$

$$= \rho \times 0.10 \times \frac{100}{\frac{3}{2}} \times \frac{1}{5280}$$

And for the ring between circles 1 and 2

$$A = \rho\frac{2}{3}\;\frac{1}{52800}[100+400+\;\ldots\ldots\;100]$$

And for the entire semicircle

$$A = \rho\frac{2}{52800}\left[\frac{13450}{3} + \frac{25950}{5}\;\ldots\ldots\;\frac{106450}{19}\right]$$

From which the deflection of the plumb-line would be 12″.8. The radius of the earth is taken as 3,960 miles and the ratio of the densities as 0.48.

For the second series we have for the compartment in sector I and between the 10th and 11th circles

$$A = \rho(\sin a_2 - \sin a_1) \log_e\left(\frac{r_2}{r_1}\right) h$$

Or

$$= \rho \times 0.10 \times .09531 \times \frac{4450}{5280}$$

And for the ring between the 10th and 11th circles

$$A = \rho \frac{.009531}{5280} [4450 + 7950 + \text{etc.}]$$

And for the semicircular space between the 10th and 20th circles

$$A = \frac{.009531}{5280} [97800 + 86750 + \text{etc.}]$$

From which the deflection of the plumb-line would be 4″.1.

For the third series the deflection is

$$0.0026(\sin a_2 - \sin a_1) \log_{10}\left(\frac{r_2}{r_1}\right) h$$

With the following data:

Space.	h	a_2	a_1	r_2	r'
		°	°	M.	M.
Lahaina.	2500	64	53	39.5	29.3
Wailuku.	1500	53	44	40.8	33.2

The deflections are:

	″
Lahaina	0.08
Wailuku	0.04
Sum	0.12

Hence the total effect of the matter lying above the sea is 17″.0.

Results of pendulum observations on Maui.

The time of one oscillation at Haiku being corrected for latitude by the formula $\Delta N = [2.35305] \sin^2 \lambda$ and for elevation by

$$g_{h=0} = g_{h=z}\left(1 + \frac{5z}{4r}\right)$$

it is then compared with the period at Pakaoao. The ratio of the mean density of the mountain to that of the earth is obtained by

$$\frac{dg}{g} = \frac{2h}{r}\left(1 - 0.63\,\frac{\delta}{\Delta}\right)$$

Making the result depend on all the observations and reducing on the principle of the reversible pendulum we get $\delta = 0.479\Delta$.

This last formula is derived by comparing the attraction of a sphere $\left(\frac{4}{3}\pi \Delta r\right)$ with that of a cone on a particle at its apex $[2\pi\delta\,(1 - \cos\beta)h]$ from which it results that the earth's attraction is $\dfrac{\Delta r}{3\delta h \sin^2 \frac{\beta}{2}}$ times that of the mountain; where

Δ = the density of the earth,
δ = the density of the mountain,
r = the radius of the earth,
h = the height, and
β = the semivertical angle of the mountain.

The density of the sea being $\frac{1}{5.6}$ and that of rock being $\frac{1}{2}$ the earth's mean density, the influence of the sea would be that of matter of density $\frac{3.6}{11.2}$. Hence its effect would be to add to the land attraction $\frac{7.2}{11.2}$ of itself, which would give for the total effect at Ka Lae o Ka Ilio 27''.9. That found by triangulation was 29''.4.

Density of the surface rock.

Twelve specimens of rock from different parts of the islands were secured. They have had their densities determined in the Bureau of Weights and Measures at the Coast and Geodetic Survey Office and four typical specimens were examined at the U. S. National Museum. The following are the densities furnished by Mr. O. H. Tittmann, Assistant Coast and Geodetic Survey, in charge of Weights and Measures, under whose direction the densities were determined:

No. of specimen.	Remarks by collector.	Density.
1	Drop of lava, Maui.	2.15
2	Pahoehoe, flow of 1881, Hawaii.	2.26
3	Do.	2.55
4	Aa, Maui.	2.45
5	Magnetic Kolekole, Maui.	2.58
6	Colored purple, Hawaii.	2.67
7	Colored purple, Maui.	1.76
8	Perforated sheet, Maui.	2.05
9	Porous, purple, Maui.	2.05
10	Do.	2.03
11	Sand tube, Kauai.	2.42
12	Pumice, Maui.	1.60

The mean density of all is 2.21 while the mean of the Maui specimens gives 2.09. This last value is 0.37 of the usually accepted value of the earth's density.

Mr. George P. Merrill, curator of the Department of Lithology, U. S. National Museum, has kindly furnished the following description:

"The rocks examined are all basalts, differing only in degree of crystallization."

No. 3. "This is a most beautiful illustration of the glassy structure assumed by a rock on rapid cooling. The specimen is from the upper surface of the flow, of a decided glassy aspect, and almost coal-black in color. Sections cut across the direction of the flow show the upper portion for a depth of half an inch to be composed of a deep, brownish glass, perfectly amorphous, bearing numerous skeleton forms of feldspar, olivines, and very faintly-greenish monoclinic pyroxenes. All occur either as mere skeletons, imperfectly separated from the base, or as sharply outlined crystals. An occasional olivine was observed, which is evidently a product of earlier secretions from the magma and has suffered from corrosion. In the immediate vicinity of the crystal secretions the glass becomes darker in color and partially devitrified, forming a narrow,

nearly black halo about each mineral. Beyond the half-inch limit the glass base rapidly deepens in color, becoming more and more devitrified until it resembles that of No. 6, to be described later."

No. 4. "This, as seen under the microscope, consists of a very dense though vesicular ground mass of deep brownish-black color, and very opaque, bearing abundant small porphyritic plagioclases and scattering augites and olivines. The plagioclases are greatly elongated, almost needle-like, but very fresh, and in most cases distinctly striated by one, or rarely more, twining bands. The olivines and augites are both in the form of imperfectly developed crystals, sometimes showing quite perfect crystal outlines, and very rarely showing any signs of corrosive action from the molten magma. The ground mass consists of an exceedingly dense aggregate of minute feldspar microlites and opaque ferruginous particles imbedded in a deep brownish, almost completely devitrified base."

No. 6. "This is similar to No. 4, but the base is completely devitrified, presenting the characteristic tufted and fibrous structure of the hyalo basalts from the Vogelsburg, but more nearly opaque. The olivines often present beautiful, sharp, crystal outlines with steep, dormal faces and carrying only inclusions of pale, brownish glass. The iron ores, as in the last, occur only as a dust-like powder, and never in recognized crystalline form."

No. 7. "Is a very porous pumice, of evidently the same lithological nature, but so rotten that attempts at making sections do not yield satisfactory results."

If we accept 0.48 $\varDelta$ as the value of δ, and take 5.67 for the earth's mean density, that of the mountain becomes 2.7. This is somewhat larger than the specific gravity of the rocks examined. Prof. E. S. Dana, in the American Journal of Science for June, 1889, has made a very thorough study of the Hawaiian lavas. The mean of fourteen of his specimens, freed from air by boiling, gives 3.0. In the determinations at this office the air was not expelled. The value, 2.7, as previously stated, depends on all the pendulum observations in both positions. The mountain is considered as a cone and not as a plain of infinite extent. The conclusion is that the mean density of Haleakala is at least equal to the average density of the rocks of the islands. This result was announced in a paper read before the American Association at the Cleveland meeting, August, 1888.

Reduction of the time observations.

The time of the transit of each star across the mean thread is corrected for rate of chronometer, inclination of axis, and diurnal aberration. This corrected transit compared with the star's right ascension gives a quantity called τ, and each star furnishes a conditional equation of the form

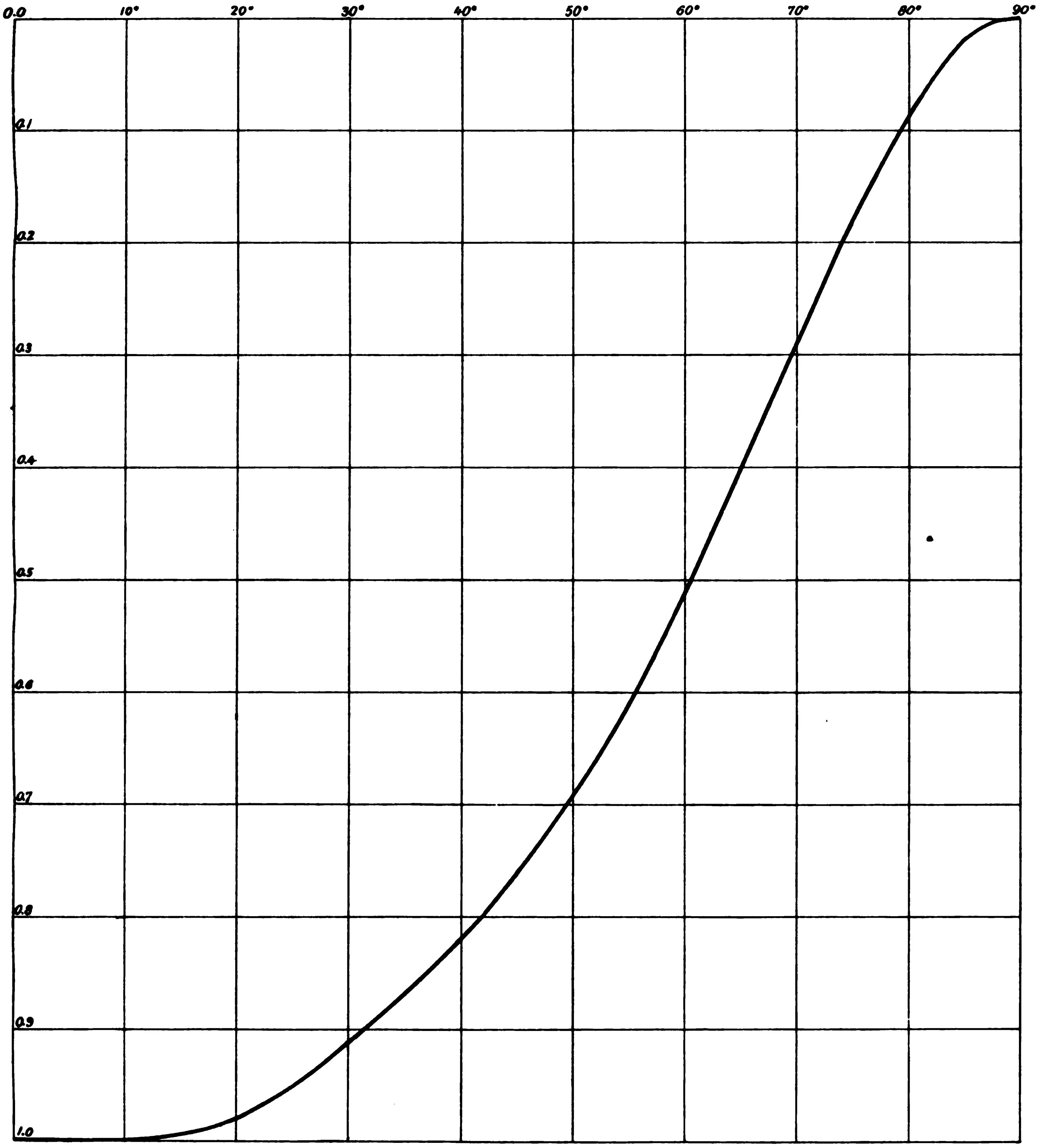
$$\delta T + aA = \tau$$

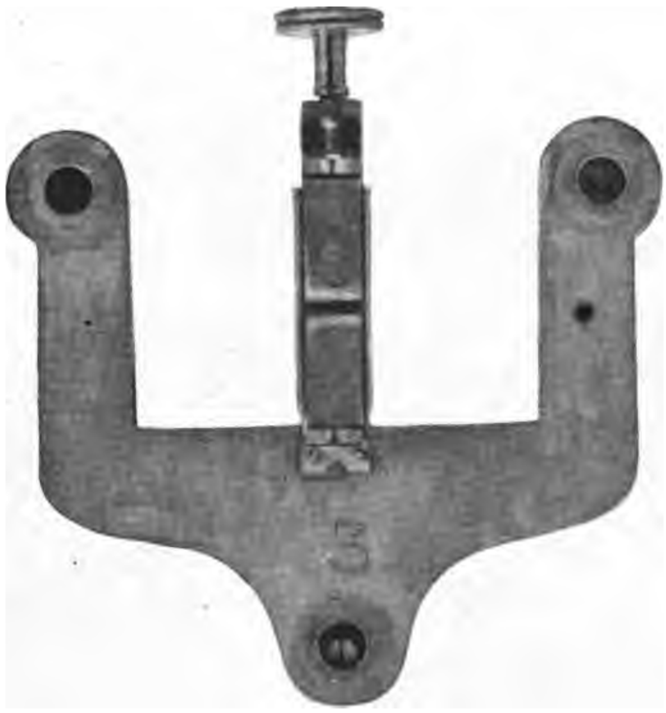
The two unknown quantities being the chronometer correction and the azimuth. Each observation receiving a weight (p) depending on the star's declination and the number of threads observed, the conditional equations are reduced to the same unit of weight by multiplying by $\sqrt{p}$. The normal equations are then formed in the usual way. Separate azimuths are determined for the two positions of the instrument. A reduction is first made with an approximate value of the collimation, and the two values of δT are brought together by correcting this first approximation.

The following table gives the reduction by the application of the method of least squares, beginning with the quantities τ above mentioned. The column d is simply the difference between τ and an assumed value for $\varDelta T$, for the sake of dealing with smaller numbers. The column A contains the azimuth factors. The last column $p\varDelta$ gives the residuals on a uniform scale.

The curve of weights (illustration No. 52) is plotted from the table given in Appendix No. 14, Coast and Geodetic Report for 1880.

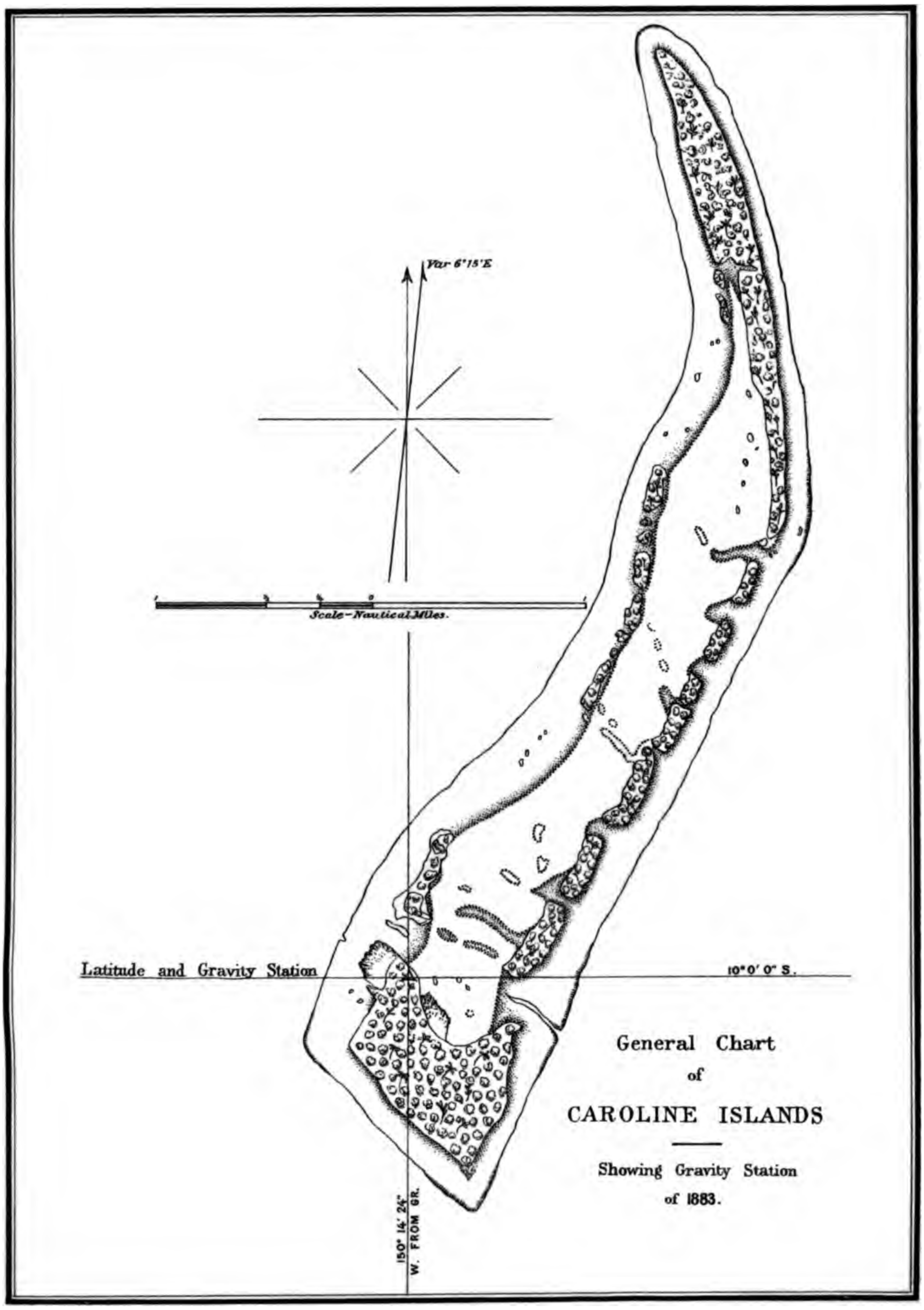
Relative Weights depending on Star's Declination





PENDULUM HEAD No. 3.

PENDULUM STAND, 1883.



General Chart
of
CAROLINE ISLANDS

Showing Gravity Station
of 1883.

Reduction of time observations.

PAKAOAO, JULY 5, 1889.

CLAMP WEST.

Star.	τ	d	A	p	pA	pA^2	pd	pAd	aA	ΔT	Δ	$p\Delta$
	s.											
π Bootis.	+49.62	+0.02	+0.07	0.99	+0.07	0.00	+0.02	0.00	+0.05	49.57	+0.04	+0.04
μ Virginis.	49.91	+0.31	+0.44	1.00	+0.44	0.19	+0.31	+0.14	+0.33	49.58	+0.03	+0.03
ϵ Bootis.	49.62	+0.02	−0.14	0.93	−0.13	0.02	+0.02	0.00	−0.11	49.73	−0.12	−0.11
Groom. 2164.	48.66	−0.94	−1.25	0.52	−0.65	0.81	−0.49	+0.61	−0.94	49.60	−0.01	+0.00
P XIV.	49.66	+0.06	+0.11	1.00	+0.11	0.01	+0.06	+0.01	+0.08	49.54	+0.07	+0.07
				4.44	−0.16	1.03	−0.08	+0.76				−0.03

CLAMP EAST.

Star.	τ	d	A	p	pA	pA^2	pd	pAd	aA	ΔT	Δ	$p\Delta$
1 H. Urs.	48.34	−1.26	−1.93	0.34	−0.66	1.27	−0.43	+0.83	−1.27	49.61	0.00	0.00
β Cor. Bor.	49.48	−0.12	−0.18	0.91	−0.16	0.03	−0.11	+0.02	−0.12	49.60	+0.01	−0.01
ν Bootis (pr.).	49.35	−0.25	−0.46	0.80	−0.37	0.17	−0.20	+0.09	−0.30	49.65	−0.04	−0.03
α Cor. Bor.	49.55	−0.05	−0.12	0.93	−0.11	0.01	−0.05	+0.01	−0.08	49.63	−0.02	−0.02
α Serpent.	49.83	+0.23	+0.24	1.00	+0.24	0.05	+0.23	+0.06	−0.16	49.67	−0.06	−0.06
β Serpent.	49.55	−0.05	+0.09	1.00	+0.09	0.01	−0.05	0.00	+0.06	49.49	+0.12	+0.12
				4.98	−0.97	1.54	−0.61	+1.01				0.00

Normal equations.

West.

$$4.44\,\delta T - 0.16\,a = -0.08$$
$$-0.16\,\delta T + 1.03\,a = +0.76$$

$$a_w = +0.75$$
$$\delta T = +0.01$$

East.

$$4.98\,\delta T - 0.97\,a = -0.61$$
$$-0.97\,\delta T + 1.54\,a = +1.01$$

$$a_e = +0.66$$
$$\delta T = +0.01$$

At $15^h\ 00^m$ $\Delta T = +0^m\ 49^s.61$.

Observations of 1883.

The occupation of Caroline Island, Polynesia (see illustration No. 53), by the U. S. Solar Eclipse Expedition, offered facilities for the determination of gravity in widely different latitudes. Instructions were therefore given by the Superintendent of the Coast and Geodetic Survey for pendulum observations at the eclipse station, at Honolulu and Lahaina in the Hawaiian Islands, and at San Francisco. Pendulum No. 3 was used at these four stations together with a wooden stand (illustration No. 55) and head No. 3 (illustration No. 56).

The extreme range between the day and night temperature at Caroline Island and at Lahaina made it preferable to swing only at night. At Honolulu and San Francisco the work was continued through the entire twenty-four hours. The methods of observation and reduction are similar to those employed in the work of 1887.

Description of stations.

Caroline Island.—The station was situated on the southernmost of the group of islets and the position is indicated in illustration No. 53. The height above mean tide is 7 feet.

Lahaina.—The point occupied was identical with that of De Freycinet in 1819. The general locality was found by means of his own map of the neighborhood, although the shore-line had changed somewhat during the sixty years. Two very conclusive proofs exist that the stations are the same, viz, that an old Kanaka who had seen the observations of 1819, testified to the correctness of the position; and that in digging for the foundation of the pier some sun-burnt bricks used

by De Freycinet were unearthed. Its location with reference to the present village is shown in illustration No. 54 kindly furnished by Mr. S. E. Bishop, of the Government Survey. The height of the pendulum above mean tide was 10 feet.

Honolulu.—The cellar of the Young Men's Christian Association building was used. It is situated at the corner of Hotel and Alakea streets. Height of pendulum above mean tide was 12 feet.

San Francisco.—Davidson Observatory, as in the work of 1887.

Time and latitude were determined with a transit instrument instead of a meridian telescope. A delicate level was attached to one of the setting circles of transit No. 2, and latitude was observed by the method of equal zenith distances, the telescope being lifted from the Y's and revolved 180° between the two stars of each pair. A cam turned by means of a crank (see illustration No. 48) facilitated this movement and enabled the observer to take stars having a difference of one minute in right ascension.

Transit No. 2 has a focal length of 46 inches, with an aperture of $2\frac{3}{8}$ inches. A diagonal eyepiece giving a power of 110 was used. One division of the latitude level is equal to $1''.75$. That of the striding level is $0''.83$. One revolution of the micrometers equals $43''.44$.

Sidereal chronometer, Negus No. 1589, was used for all time and pendulum observations. Hutton No. 202, also sidereal, was compared with it twice daily. Negus breaks the circuit every even second except the sixtieth. Hutton breaks every even second and the fifty-ninth. A chronograph similar to the one shown in illustration No. 50 was used in recording the time and pendulum observations. Illustration No. 57 shows a front and side view of pendulum No. 3. No. 4 is of a similar construction, the only difference being in the length of the bar.

Length of pendulums and position of center of mass.

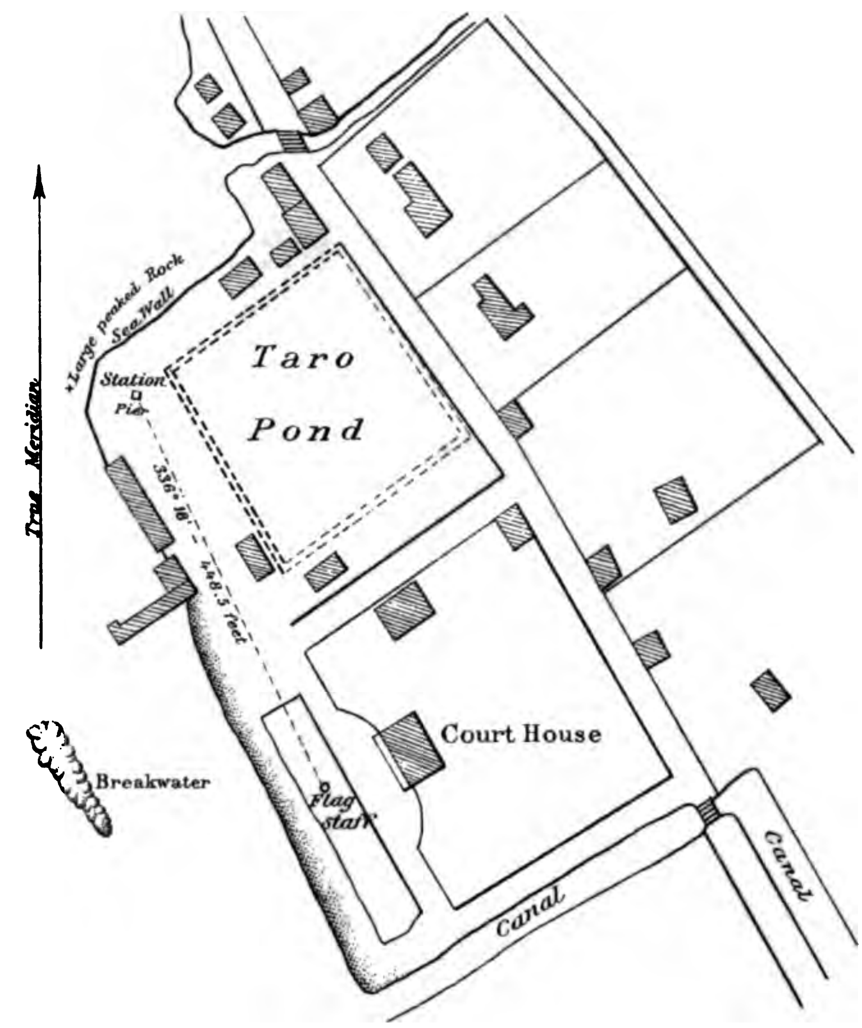
Although the character of the gravity work is entirely differential, as it was desirable to reduce it both on the principle of the reversible and on that of the invariable pendulum, the lengths and positions of the center of mass of pendulums No. 3 and No. 4 were determined. They were compared with the "Yard and Metre No. 1" belonging to the Bureau of Weights and Measures, by means of the Repsold vertical comparator (see illustration No. 58).

A modification of the usual method of illuminating the knife edge was devised by Mr. O. H. Tittmann, in charge of the Bureau of Weights and Measures. A highly polished steel plane was placed between the upper knife edge and the plane on which the pendulum usually swings. The line of collimation of the microscope was brought to the same level as the line of contact between the knife edge and the steel plane. A small right-angled triangular prism was placed near the objective in such a manner as to throw the light by total reflection through a small hole in the pendulum and illuminate the point of intersection of the axis of collimation and the line of contact above mentioned. This gave a direct and reflected image of the edge, the space between the two being a dark band whose width depended on the distance of the edge from the plane. Measures were made on the center of the band, and these being corrected for its half-width gave the position of the edge.

A similar disposition held for the measures on the lower knife edge. The light was furnished by an incandescent burner of a three-candle power from a bichromate of soda battery of four cells. The light was concentrated on the prism by a lens of 2 feet focal length. The illumination on the metre was direct, a small conical cap of white paper being placed over the burner to diminish its brilliancy. After a number of measures with this illumination the light was placed directly behind the pendulum and measures were made on the dark edge, the field being made bright enough to make the threads visible when projected upon the edge. The results by the two methods agree satisfactorily.

The center of mass measures were made on the Repsold apparatus slightly modified in order to fit the Peirce pendulums. As the difference between the times of oscillation in the two positions of the pendulum are $0^s.00003$ for No. 4 and $0^s.0002$ for No. 3, the position of the center of mass need not be determined closer than to the nearest millimetre.

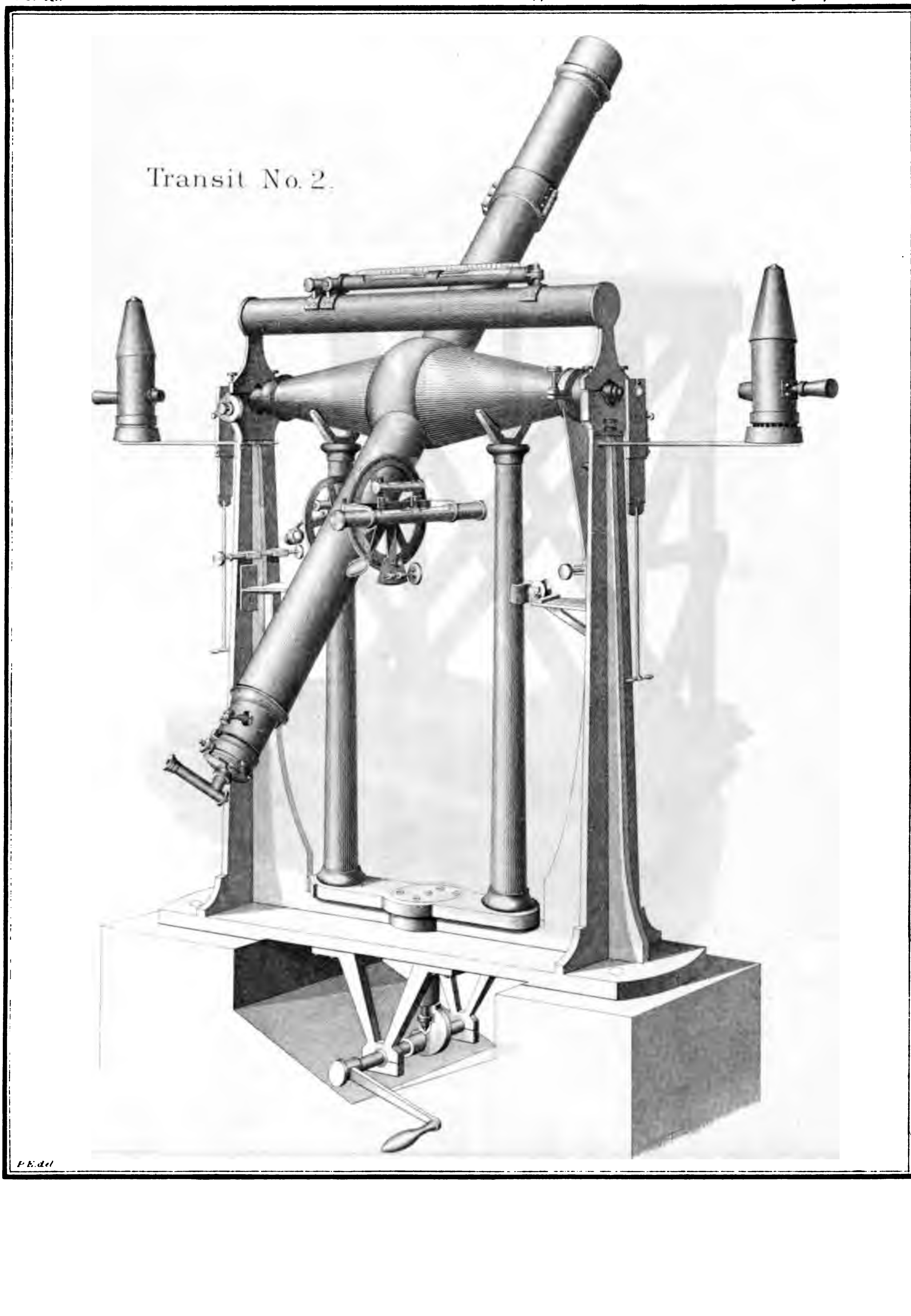
In the length measures, although the true edge at the point measured is not in perfect contact with the plane, as is made evident by the perceptible thickness of the dark band, yet the middle of this band should be considered as marking the line about which the pendulum oscillates.



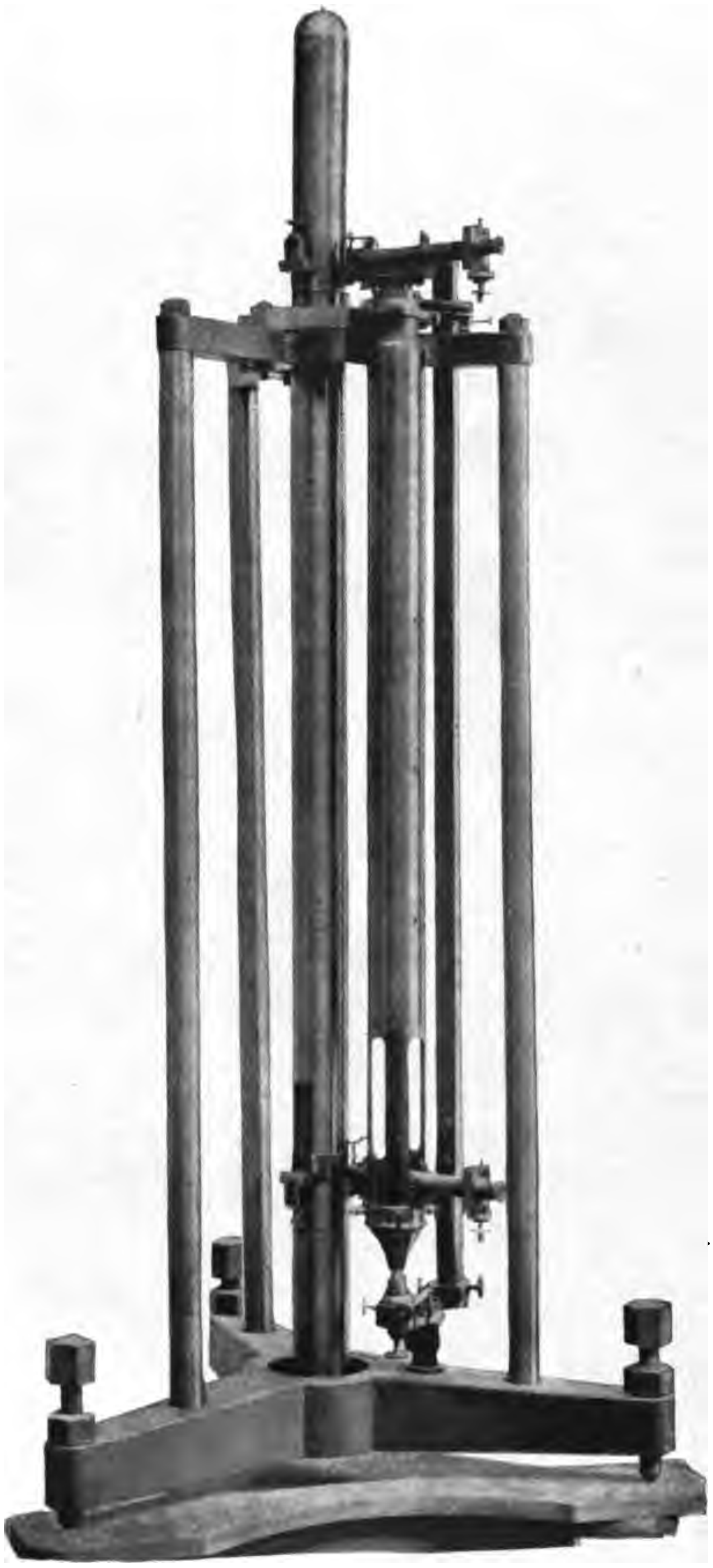
Gravity and Latitude Station

LAHAINA, MAUI

Scale :


Transit No. 2.
P.E. del

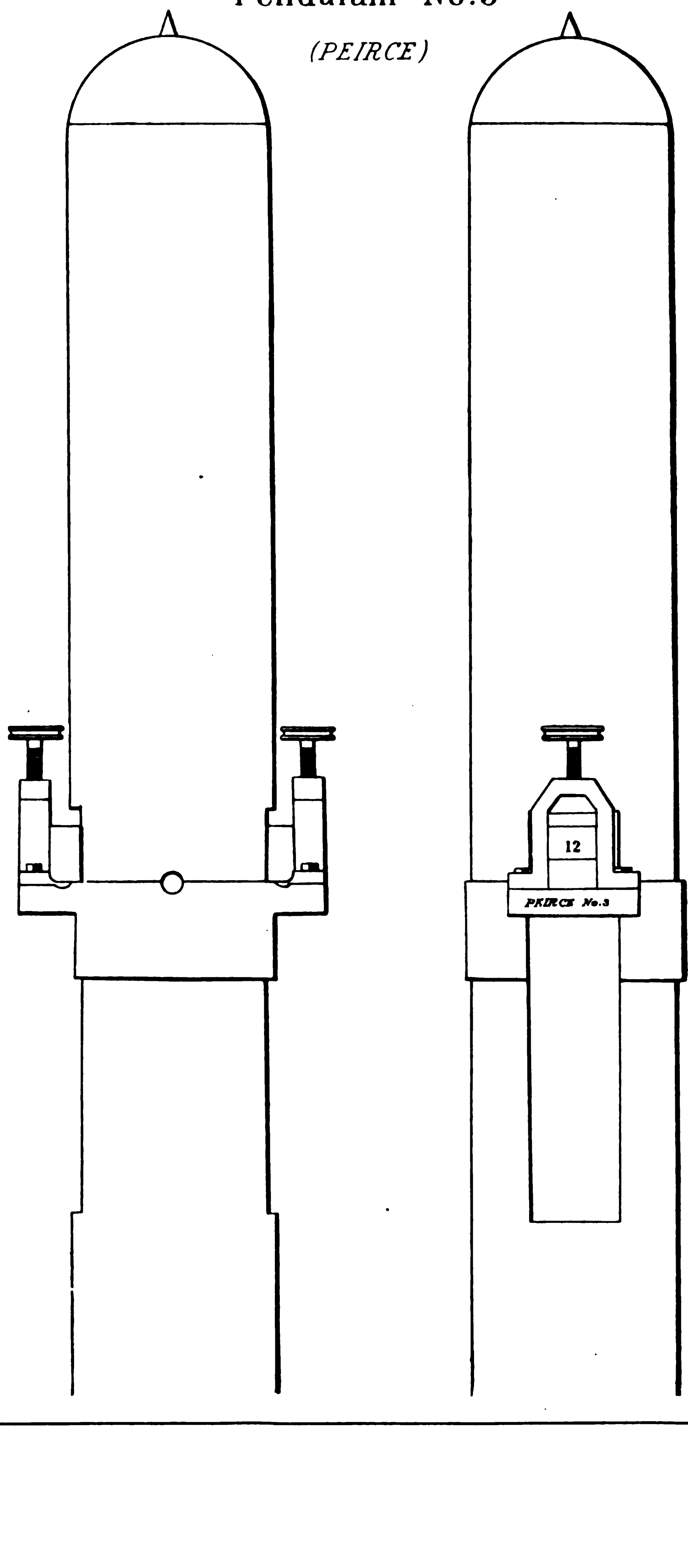
PENDULUM STAND, 1887.

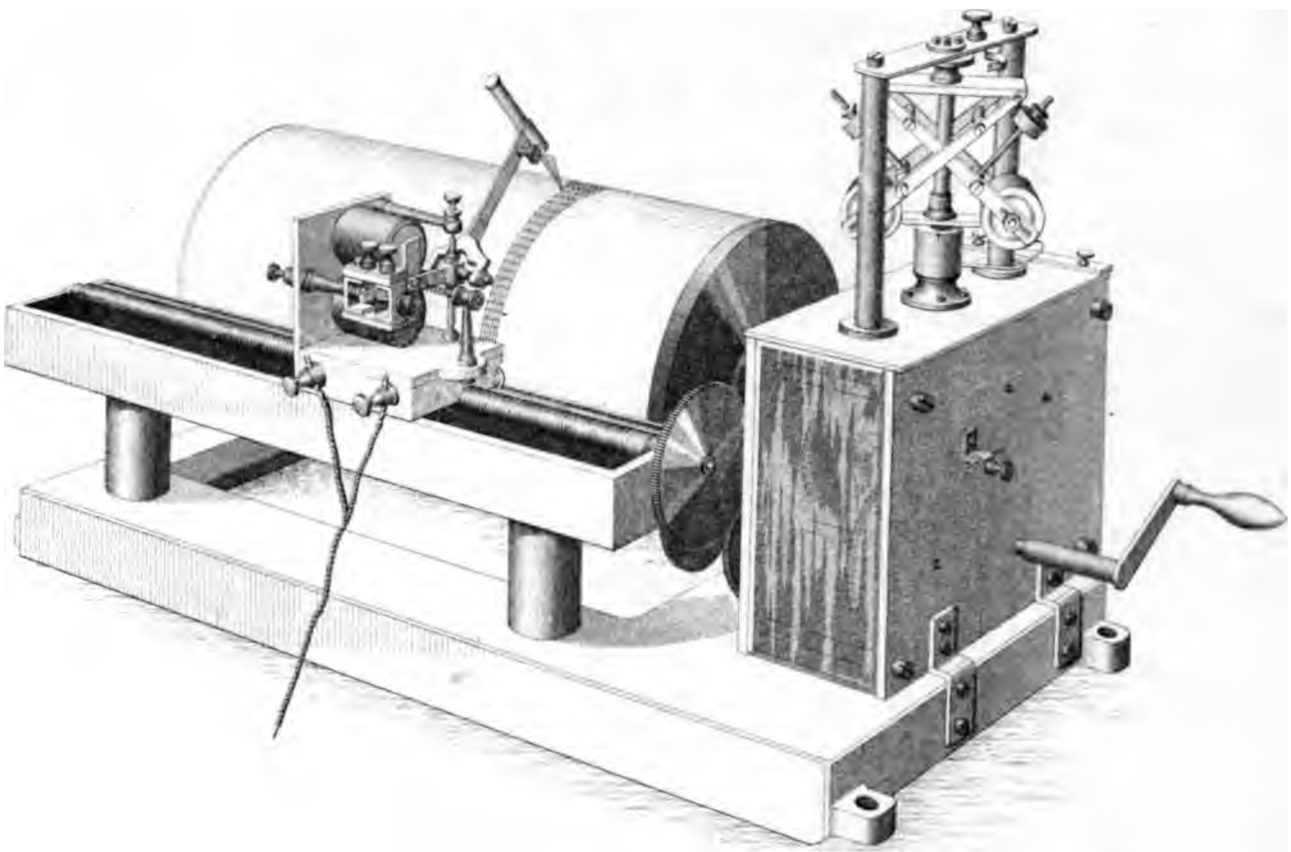


Repsold Vertical Comparator, with Pendulum No. 4 and "Y and M No. 1" in position.

Pendulum No. 3

(PEIRCE)





CHRONOGRAPH.

: del.

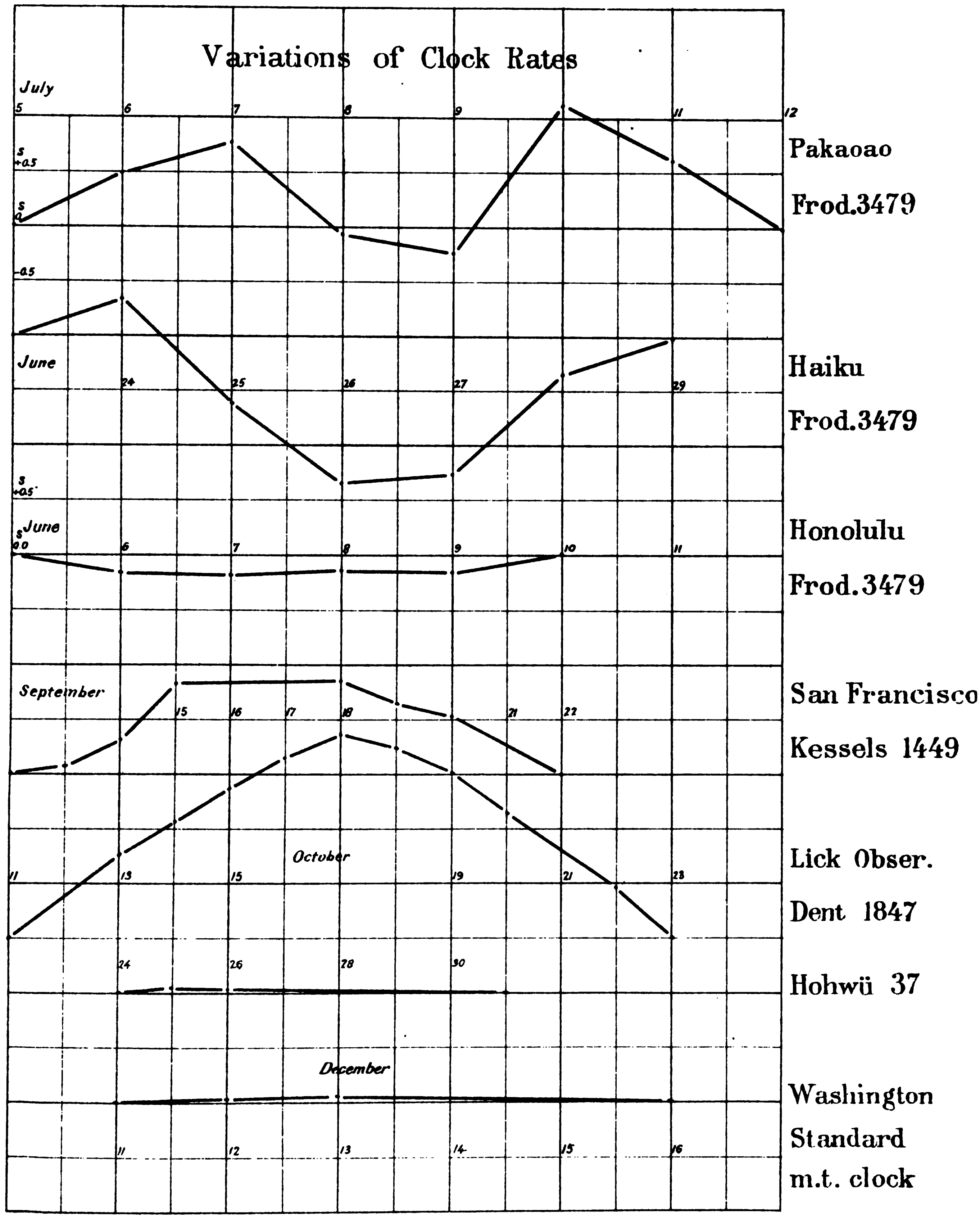
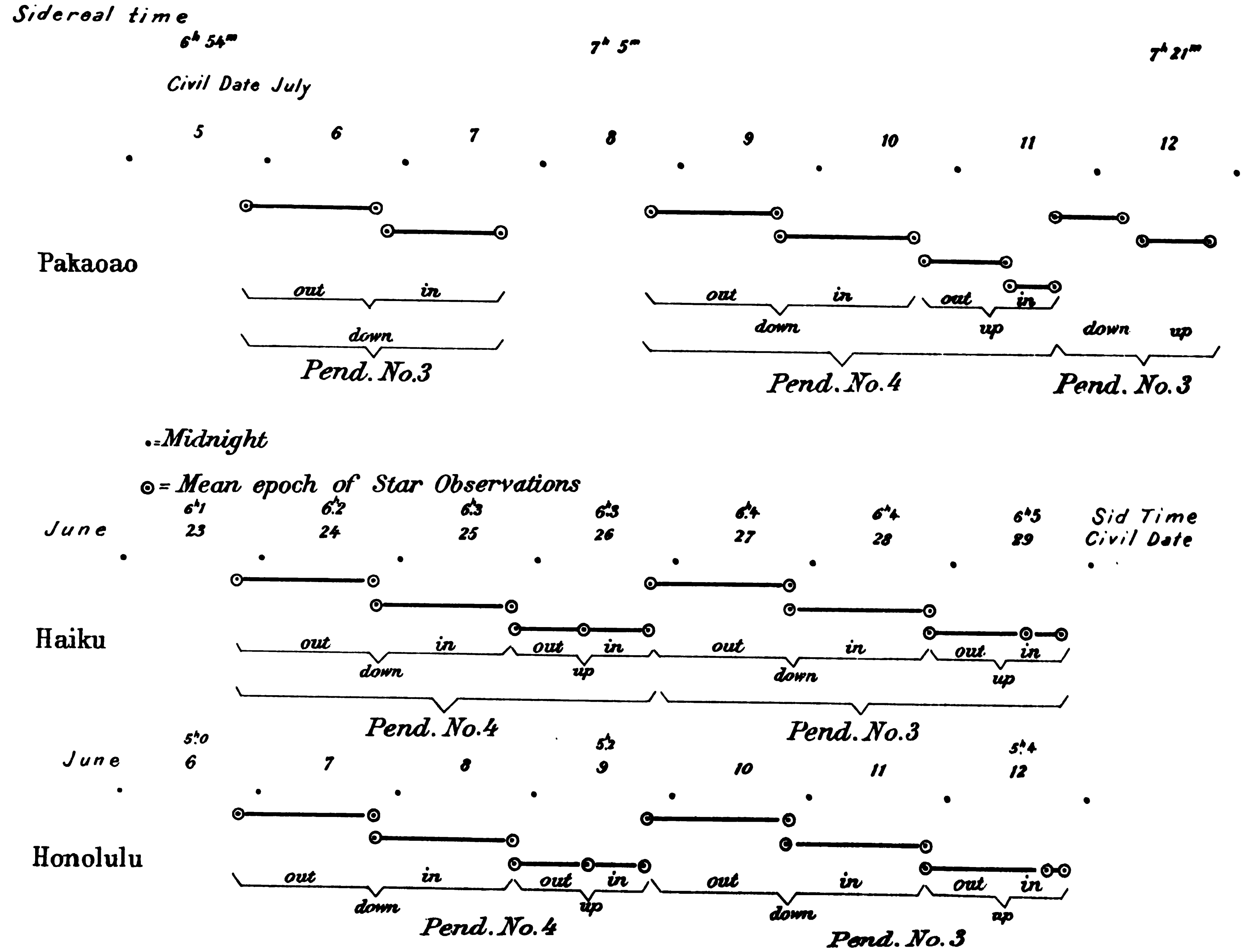

Variations of Clock Rates
July
Pakaoao
Frod.3479
June
Haiku
Frod.3479
June
Honolulu
Frod.3479
September
San Francisco
Kessels 1449
October
Lick Obser.
Dent 1847
Hohwü 37
December
Washington
Standard
m.t. clock

Diagram showing relative times of star observations and pendulum swings.



If the steel surface is a perfect plane and the pendulum is resting upon it, certainly we have here conditions precisely similar to those existing when the gravity observations are made; and the best value for the position of the line is that given by the surface of the plane, or the mean of the direct and reflected images.

We have then the following values for the lengths and positions of the center of mass of pendulums No. 3 and No. 4, in terms of "Yard and Metre No. 1." Measures made in April and May, 1889. Temperature Centigrade.

Pendulum No. 3 ($18^\circ.60$) = 35.9960 inches ($18^\circ.78$).
Pendulum No. 4 ($21^\circ.66$) = 0.999938 metres ($21^\circ.72$).
Pendulum No. 3 h_d = 26.74 + inches.
h_u = 9.25 + inches.
Pendulum No. 4 h_d = 0.7485 metres.
h_u = 0.2514 metres.

The temperatures are corrected for scale error, zero point, interior pressure and calibration, and are reduced to the hydrogen scale.

On "Yard and Metre No. 1" the yard has been compared with the British Bronze Yard No. 11, and the metre has been compared with "Yard and Metre No. 2," with the Berlin Metre No. 49 and with the U. S. Lake Survey Standard. "Yard and Metre No. 2" has been compared at Paris with the international provisional metre. The following equations are furnished by Mr. O. H. Tittmann:

Yard and Metre No. 1:

$$\text{Yard} = 1 \text{ yard} + (t - 61^\circ.17 \text{ Fahr.}) \times .000010 \text{ yard.}$$
$$\text{Metre} = 1.0003056 \text{ metres} + (t - 17^\circ.48 \text{ C}) \times 18^\mu.$$

From these and the preceding equations we get:

Pendulum No. 3 at $18^\circ.60$ C. (= $65^\circ.48$ Fahr.) = 35.9977 inches.
Pendulum No. 4 at $21^\circ.66$ C. = 1.000320 metres.

That neither of the pendulums suffered any violent change during the ten months is evident from the following table:

Difference between pendulums No. 3 and No. 4.

Station.	One oscillation.		Seconds per day.	
	Down.	Up.	Down.	Up.
	s.	s.		
Pakaoao.	0.044360	0.044524	3832.7	3846.9
Haiku.	58	517	2.5	6.3
Honolulu.	60	523	2.7	6.8
San Francisco.	59	497	2.6	4.5
Lick Observatory.	58	509	2.5	5.6
Washington.	53	516	2.1	6.2

The following tables give the instrumental constants, chronometer corrections, and star residuals for each station. Illustration No. 59 shows graphically the variations of the rates after correcting for a uniform rate from the beginning to the end of the observations. The corrections for temperature and pressure in the pendulum summary are to reduce to the mean for the station. The wide range in the individual values for Pakaoao is due to three causes: First, the great range of temperature; second, the irregular rate of the chronometer which was necessarily much disturbed by its journey up the mountain, and, third, the wind, which in spite of all precaution penetrated to a slight extent into the pendulum-house. Illustration No. 60 shows the relation of the swings for the island stations to the time of star observations.

Instrumental constants and chronometer corrections.

PAKAOAO.

[Meridian Telescope No. I, Frod. Sid. Chro. 3479.]

Date.		Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Collimation.	δt	$\Delta \delta t$
		h. m.	s.	s.	s.	s.	s.	m. s.	s.
July	5	15 0	0.00	0.00	+ 0.66	+ 0.75	0.00	+ 0 49.61	
	6	15 0	+ 0.05	0.00	+ 4.93	+ 4.77	— 0.08	53.36	+ 3.75
	7	15 0	+ 0.03	+ 0.07	+ 0.48	+ 0.59	+ 0.21	57.31	+ 3.95
	8	14 30	+ 0.03	+ 0.05	+ 1.91	+ 1.91	+ 0.11	62.31	+ 5.00
	9	15 00	— 0.07	+ 0.15	— 0.85	— 0.94	+ 0.11	66.79	+ 4.48
	10	14 30	0.00	— 0.02	— 0.65	— 0.41	+ 0.27	69.62	+ 2.83
	11	14 20	+ 0.06	— 0.07	— 0.92	— 0.52	+ 0.14	74.33	+ 4.71
	12	14 50	+ 0.02	— 0.06	— 0.05	— 1.75	+ 0.25	79.33	+ 5.00

HAIKU.

[Meridian Telescope No. I; Frod. Sid. Chro. 3479.

Date.		Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Collimation.	δt	$\Delta \delta t$
June	23	13 30	— 0.12	— 0.10	— 1.51	— 1.62	— 0.15	+ 6 16.64	
	24	13 30	— 0.31	— 0.39	— 1.76	— 2.49	— 0.09	16.32	— 0.32
	25	13 30	+ 0.05	— 0.04	+ 1.02		+ 0.17	17.33	+ 1.01
	26	13 30	+ 0.20	— 0.04	+ 0.50	+ 0.50	+ 0.08	18.08	+ 0.75
	27	14 00	+ 0.04	— 0.06	+ 0.69	+ 0.80	+ 0.09	18.05	— 0.03
	28	14 00	+ 0.08	— 0.03	+ 0.38	+ 0.60	+ 0.12	17.17	— 0.88
	29	13 30	+ 0.14	— 0.02	+ 0.08	+ 0.36	+ 0.04	16.88	— 0.29

HONOLULU.

[Meridian Telescope No. I; Frod. Sid. Chro. 3479.]

Date.		Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Collimation.	δt	$\Delta \delta t$
June	6	12 20	+ 0.19	+ 0.06	— 0.62	— 0.22	— 0.65	+ 0 15.05	
	7	14 20	+ 0.07	+ 0.03	+ 2.04	+ 1.51	+ 0.04	15.07	+ 0.02
	8	14 00	+ 0.06	— 0.02	+ 1.76	+ 2.14	+ 0.09	14.92	— 0.15
	9	12 30	+ 0.09	+ 0.02	— 0.45	— 0.60	0.00	14.80	— 0.12
	10	13 00	+ 0.02	— 0.10	— 0.29	— 0.21	+ 0.02	14.72	— 0.08
	11	13 30	— 0.03	0.00	— 0.18	— 0.21	+ 0.02	14.42	— 0.30
	12	12 30	+ 0.01	— 0.10	— 0.26	— 0.35	+ 0.03	14.30	— 0.12

SAN FRANCISCO.

[Transit; Kessels Sid. Clock 1449.]

Date.		Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Collimation.	δt	$\Delta \delta t$
Sept.	12	19 40	— 0.05	— 0.33	— 0.11	— 0.16	— 0.15	— 2 0.37	
	13	19 00	+ 0.02	— 0.28	— 0.25	0.00	— 0.12	1.69	— 1.32
	14	19 00	+ 0.01	— 0.25	0.00	— 0.28	— 0.23	3.17	— 1.48
	15	19 00	+ 0.01	— 0.18	— 0.10	— 0.18	— 0.18	4.97	— 1.80
	18	19 00	+ 0.04	— 0.18	0.00	— 0.20	— 0.23	8.79	— 3.82
	19	19 40	+ 0.04	— 0.20	+ 0.04	— 0.15	— 0.09	9.87	— 1.08
	20	19 40	+ 0.04	— 0.23	— 0.11	— 0.27	— 0.18	11.00	— 1.13
	22	20 00	+ 0.12	— 0.17	— 0.51	+ 0.01	— 0.10	13.03	— 2.03

Star residuals.

PAKAOAO, JULY, 1887.

Star.	Declination.	5	6	7	8	9	10	11	12
	° ′	s.	s.	s.	s.	s.	s.	s.	s.
α Draconis.	64 55		−0.01				0.00	0.00	
d Bootis.	25 38		−0.04					+0.01	
κ Virginis.	− 9 45				+0.03		−0.02	+0.04	
4 Ursæ Maj.	78 5				+0.01				
i Virginis.	− 5 28						+0.03	+0.01	
λ Virginis.	−12 51		−0.07					−0.05	
ρ Bootis.	30 52			−0.13	−0.05	+0.06		−0.05	+0.15
5 Ursæ Min.	76 12			0.00		+0.02		+0.02	
33 Bootis.	44 54			+0.14					
π Bootis.	16 54	+0.04				−0.10		+0.05	
μ Virginis.	− 5 10	+0.03	+0.11	+0.05		+0.07	0.00	+0.09	+0.03
ε Bootis.	27 33	−0.11		−0.06	−0.10	−0.07		−0.13	−0.20
Groom. 2164.	59 45	0.00			+0.03		−0.03		
P XIV 221.	14 54	+0.07							
β Ursæ Min	74 37								+0.01
β Bootis.	40 50				+0.02		+0.02		−0.01
β Libræ.	− 8 58				+0.07		−0.02		−0.10
1 H. Ursæ Min.	67 47	0.00							−0.12
μ Bootis.	37 46								0.00
β Cor. Bor	29 30	−0.01							+0.19
ν Bootis.	41 13	−0.03							
α Cor. Bor.	27 6	−0.02				−0.08			+0.08
α Serpentis.	6 47	−0.06		−0.09		−0.04			
β Serpentis.	15 47	+0.12		+0.09		+0.11			
χ Serpentis.	18 29		−0.08	0.00		+0.03			
ζ Ursæ Min.	78 8		+0.04	0.00		+0.00			
ε Cor. Bor.	27 12		−0.12						
δ Ophiuchi.	− 3 24		−0.02						
σ Cor. Bor.	34 9		+0.08						
ε Ophiuchi.	− 4 25		+0.09						

HAIKU, JUNE, 1887.

Star.	Declination.	23	24	25	26	27	28	29
	° ′	s.	s.	s.	s.	s.	s.	s.
ε Virginis.	11 34		−0.01	+0.05	−0.03			−0.02
θ Virginis.	− 4 56		−0.19		+0.04			
43 Comæ.	28 27	−0.01	+0.17	+0.05	−0.03			+0.01
20 Can. Ven.	41 10	0.00			+0.02			
ζ Ursæ Maj.	55 31						+0.02	
Polaris.	91 18	0.00	0.00		0.00			0.00
ζ Virginis.	− 0 1						+0.01	+0.08
17 H. Can. Ven.	37 46					0.00		−0.05

Star residuals—Continued.

HAIKU, JUNE, 1887—Continued.

Star.	Declination.		23	24	25	26	27	28	29
	°	′	s.	s.	s.	s.	s.	s.	s.
τ Bootis.	18	1	—0. 16				+0. 11	0. 00	+0. 08
m Virginis.	— 8	8			—0. 04		—0. 09	—0. 09	
89 Virginis.	—17	34					—0. 03	+0. 08	
i Draconis.	65	17					—0. 04		
η Bootis.	18	58			—0. 03	—0. 04			0. 00
τ Virginis.	2	5				+0. 03	+. 010		+0. 10
α Draconis.	64	55	+0. 03	—0. 03	0. 00	—0. 02			—0. 04
α Bootis.	19	46	—0. 03	—0. 09					+0. 03
d Bootis.	25	38	—0. 03	+0. 17					
κ Virginis.	— 9	45		—0. 10	—0. 01				—0. 14
ι Virginis.	— 5	27	+0. 11	+0. 06	+0. 07				
λ Virginis.	—12	51							—0. 06
5 Ursæ Min.	76	12					+0. 02		
33 Bootis.	44	54				+0. 10			
ε Bootis.	27	33					—0. 14	—0. 03	
π Bootis.	16	54						+0. 03	
μ Virginis.	— 5	10				—0. 04	+0. 01		
P XIV.	14	54					+0. 02		
β Ursæ Min.	74	37						0. 00	

HONOLULU, JUNE, 1887.

Star.	Declination.		6	7	8	9	10	11	12
	°	′	s.	s.	s.	s.	s.	s.	s.
β Leonis.	15	12				—0. 09			0. 00
β Virginis.	2	24				+0. 08			
γ Ursæ Maj.	54	19							+0. 02
π Virginis.	7	15	+0. 03			+0. 01			
ο Virginis.	9	22	—0. 03			0. 00			
δ Ursæ Maj.	57	40	—0. 01			+0. 02			
η Virginis.	— 0	2	+0. 04						
20 Comæ.	21	31		+0. 08					—0. 04
β Can. Ven.	41	58		—0. 05			+0. 02		—0. 02
κ Draconis.	70	25	—0. 03						
γ Virginis.	— 0	50	—0. 03	—0. 06					+0. 03
76 Ursæ Maj.	63	20					0. 00		
31 Cor. Bor.	28	9	0+. 01			—0. 07	—0. 05		—0. 04
32 Camel.	84	2		0. 00		0. 00			0. 00
δ Virginis.	4	0	—0. 02		—0. 10	+0. 08	+0. 07		
ε Virginis.	11	34	+0. 04	+0. 05		—0. 01	—0. 03	—0. 07	0. 00
θ Virginis.	— 4	56			+0. 02			+0. 12	—0. 03
43 Comæ.	28	27			+0. 05	—0. 02		0. 00	+0. 07
20 Can. Ven.	41	10			+0. 02			—0. 10	

Star residuals—Continued.

HONOLULU, JUNE, 1887—Continued.

Star.	Declination.	6	7	8	9	10	11	12
	° ′	s.	s.	s.	s.	s.	s.	s.
Polaris.	91 18			0.00				
Groom. 2001.	72 59					+0.01	+0.02	
ζ Virginis.	— 0 1					—0.02		
17 H. Can.	37 46					+0.02		
m Virginis.	— 8 8					+0.12		
τ Bootis.	18 1					—0.12		
τ Virginis.	2 5						+0.06	
α Draconis.	64 55			+0.03			+0.02	
d Bootis.	25 38			+0.13			+0.02	
κ Virginis.	— 9 45			+0.14			—0.01	
i Virginis.	— 5 28						+0.06	
φ Virginis.	— 1 43							
ρ Bootis.	30 52			—0.15				
33 Bootis.	44 54		+0.08					
μ Virginis.	— 5 10		+0.14					
ε Bootis.	27 33		—0.26	—0.17				
Groom. 2164.	59 45		+0.02					

SAN FRANCISCO, SEPTEMBER, 1887.

Star.	Declination.	12	13	14	15	18	19	20	22
	° ′	s.	s.	s.	s.	s.	s.	s.	s.
α Tauri.	16 17								
Groom. 848.	75 44								
τ Tauri.	22 44								
ε Ursæ Min.	97 47								
19 H. Camel.	79 6								
α Aurigæ.	45 53								
β Orion.	— 8 20								
α Lyræ.	38 41		—0.06	+0.16	—0.06	—0.04			
Groom. 2640.	65 23			—0.01	—0.02	—0.01			
110 Herculis.	20 26		0+.04	—0.05					
β Lyræ.	33 14			+0.02	+0.04	+0.03			
R Lyræ.	43 48		+0.08		+0.08	+0.08			
γ Lyræ.	32 32		—0.06	—0.09	—0.05	—0.08			
χ Cygni.	53 10	—0.06	+0.07	+0.01	+0.01		+0.01	—0.02	
τ Draconis.	73 9	+0.02	—0.03	—0.01	—0.01		0.00	+0.01	
β Cygni.	27 43	—0.06	—0.08	—0.06	—0.09		+0.08	+0.05	
θ Cygni.	49 58	—0.01	+0.02	+0.05	+0.04		—0.04	—0.02	
β Sagittæ.	17 13	+0.12	0.00	0.00	+0.06		—0.05	—0.01	--0.01
δ Sagittæ.	18 15	+0.01					—0.04	+0.04	—0.03
ε Draconis.	69 59	+0.03				—0.02	—0.05	+0.01	—0.03
ψ Cygni.	52 8	—0.07				+0.03	+0.08	—0.08	+0.07
o¹ Cygni.	46 24	--0.04				+0.04		+0.02	
24 Vulp.	24 19	+0.08				—0.06	—0.01	—0.01	—0.11
γ Cygni.	39 54								+0.14
τ Aquilæ.	6 58					0.00			
θ Cephei.	62 37								—0.04

Instrumental constants and chronometer corrections.

CAROLINE ISLAND.

[Transit No. 2. Negus Sid. Chron. 1589.]

Date, 1883.	Epoch by Chron.	Inclination.		Azimuth.		Collimation.	δt. —4h	Δ δt
		E.	W.	E.	W.			
	h. m.	s.	s.	s.	s.	s.	m. s.	
April 24	11 52	+0.69	+0.70	−3.90	−3.75	------	51 11.94	
25	8 45	−0.31	−0.36	−3.61	−3.54	−0.65	− 0 8.01	1.54
26	18 30	−0.39	−0.44	+0.58	+0.71	−0.69	− 0 6.47	
27	10 29	−0.32	−0.22	+2.94	+3.31	+0.20	− 0 0.35	1.16
28	19 00	−0.49	−0.25	+1.17	+0.81	+0.25	+ 0 0.81	
28	11 21	−0.41	−0.37	+1.05	+1.03	−0.43	+ 0 3.35	3.33
29	9 36	−0.21	−0.09	+1.14	+1.05	−0.12	0 6.68	1.32
30	18 36	−0.30	−0.13	+1.44	+1.38	−0.01	0 8.00	
30	8 50	−0.15	−0.17	+1.80	+1.80	+0.20	2 0 10.48	1.30
May 1	18 30	−0.24	−0.24	+1.52	+1.65	−0.32	1 0 11.78	
1	9 22	−0.31	−0.15	+1.71	+1.96	−0.65	0 14.15	1.17
2	19 00	−0.18	−0.17	+1.63	+1.68	−0.55	0 15.32	
4	9 31	−0.22	−0.09	+1.46	+1.49	−0.01	2 0 23.98	
5	9 29	−0.07	−0.09	+9.32	+9.39	−0.21	0 27.24	
6	10 6	−0.26	−0.08	+9.09	+9.26	−0.22	1 0 30.82	3.56
7	9 30	−0.08	−0.01	+0.20	+0.47	−0.07	0 34.38	1.28
8	18 30	−0.16	−0.07	+0.29	+0.38	−0.10	0 35.66	2.29
8	10 29	+0.04	+0.09	+0.83	+0.56	−0.17	+ 0 37.95	

Column 9 gives the change in δt between star observations used in gravity work.

On April 24 chronometer was keeping Washington sidereal time. On the 25th it was set at Caroline Island sidereal time.

HONOLULU.

Date, 1883.	Epoch.	Inclination.		Azimuth.		Collimation.	δT	Δ δt
		E.	W.	E.	W.			
	h. m.	s.	s.	s.	s.	s.	m. s.	
June 26	15 00	−0.18	−0.03	+0.56	+0.80	+0.32	− 0 26.35	3.93
27	15 00	−0.49	−0.30	+0.80	+0.80	+0.18	0 22.42	
28	15 18	−0.62	−0.53	+0.15	+0.78	+0.46	0 18.50	3.92
29	14 30	−0.67	−0.66	−0.03	+0.22	+0.10	− 0 14.90	3.60

LAHAINA.

June 10	14 00	−0.19	+0.01	+0.21	+0.24	+0.11	− 0 31.30	
11	22 00	−0.66	−0.48	+0.12	−0.01	+0.16	0 30.33	
11	14 30	−0.67	−0.96	−0.71	−0.68	+0.33	0 28.34	0.84
12	22 00	−1.50	−1.39	−0.60	−0.78	+0.35	− 0 27.50	

Instrumental constants and chronometer corrections—Continued.

LAHAINA—Continued.

Date, 1883.	Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Colli-mation.	δT	Δ/δt
	h. m.	s.	s.	s.	s.	s.	m. s.	
June 13	14 30	—0.18	+0.03	+0.25	+0.38	+0.22	—0 22.75	0.92
14	22 30	—0.44	—0.28	+0.29	+0.37	+0.21	0 21.83	
14	15 00	—0.65	—0.65	+0.19	+0.05	+0.17	0 19.98	0.94
15	22 30	—0.90	—0.96	+0.15	+0.05	+1.72	0 19.04	
16	14 00	—1.68	—1.50	+0.34	+0.26	—0.07	0 13.83	0.97
17	22 40	—1.75	—1.71	—0.86	—0.87	—0.05	0 12.96	
18	14 30	—0.36	—0.32	—1.38	—1.22	—0.07	0 8.01	0.89
19	22 40	—0.48	—0.48	—1.17	—1.32	—0.01	0 7.12	
19	14 50	—0.59	—0.55	—0.54	—0.78	0.00	0 5.04	0.88
20	22 30	—0.72	—0.57	—0.62	—0.65	0.00	—0 4.16	

SAN FRANCISCO.

[Transit No. 3. Sid. Chron. Negus 1589.]

Date, 1883.	Epoch.	Inclination. E.	Inclination. W.	Azimuth. E.	Azimuth. W.	Colli-mation.	δT	Δ/δt
July 15	16 00	+0.41	—0.08	+0.05	+0.01	—0.40	— 0 55.62	9.34
19	17 00	+0.24	+0.06	—0.16	—0.04	—0.38	0 46.28	1.72
20	16 00	+0.37	+0.14	+0.13	+0.06	—0.43	0 44.56	
27	17 00	+0.48	+0.26	—0.18	+0.11	—0.35	*0 51.19	3.25
28	16 30	+0.53	+0.30	—0.08	—0.09	—0.30	—*0 47.94	

* Sid. Chron. Hutton 202.

Star residuals.

CAROLINE ISLAND. $\varphi = -10° 00'$

Star.	δ	April. 24	25	27	28	29	30	May. 1	4	5	6	7	8
	° ′	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
α Argus.	—52 38	+0.01											
α Can. Maj.	—16 34	—0.06											
ε Can. Maj.	—28 49	+0.07											
δ Can. Maj.	—26 13	—0.02											
α Can. Min.	5 31	0.00											
β Gemini.	28 18	+0.02											
β Cancri.	9 32		—0.04										
31 Lyncis.	43 34		+0.02										
Br. 1197.	— 3 32						—0.01						
δ Hydræ.	+ 6 6						+0.03						
α Mali.	—32 47						0.00						
ε Hydræ.	6 51									—0.1			

Star residuals—Continued.

CAROLINE ISLAND—Continued.

Star.	δ	April.						May.					
		24	25	27	28	29	30	1	4	5	6	7	8
	° ′		s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
ζ Hydræ.	6 23		+0.01					−0.01	−0.4	−0.5			
i Urs. Maj.	48 30						−0.1	+0.01					
α Cancri.	12 18		+0.11							−0.3			
χ Urs. Maj.	47 37		−0.02			−0.02							
κ Cancri.	11 08		−0.02			−0.15	−0.03	+0.04	0.00			+0.02	
θ Hydræ.	2 48					+0.02	+0.05	−0.03	+0.04	+0.06	0.00	−0.01	
β Argus.	−69 14							−0.02	+0.01	+0.06	+0.09	0.00	
40 Lyncis.	+34 53					+0.09							
α Hydræ.	− 8 09		−0.07			+0.08	−0.03	+0.04	+0.06		−0.02	0.00	
10 Leonis.	36 55							−0.09	−0.14			−0.01	
ο Leonis.	10 25										+0.04		
ε Leonis.	24 19												
υ Urs. Maj.	59 35											0.00	
6 Sext.	− 3 42					0.00		+0.06	−0.06	+0.05		0.00	
π Leonis.	8 36			+0.04		+0.02		0.00	+0.02	+0.05	−0.11	+0.08	−0.06
α Leonis.	12 32												−0.04
λ Hydræ.	−11 47			−0.03						−0.01	−0.03	−0.04	−0.01
λ Urs. Maj.	43 30												+0.02
μ Urs. Maj.	42 5			−0.01		−0.01			+0.09	−0.13	−0.04		
μ Hydræ.	−16 15									+0.04			
α Antill.	−30 29			−0.03									
ρ Leonis.	9 54										−0.02		
33 Sext.	− 1 08												+0.10
τ Hydræ.	−15 53			−0.08									+0.07
d Leonis.	4 15			+0.05									
α Urs. Maj.	62 23				−0.05						−0.03		−0.03
χ Leonis.	7 58										+0.12		+0.09
β Crater.	−22 12			+0.07	−0.05						0.00		−0.12
δ Leonis.	21 10				+0.16								
σ Leonis.	6 40				−0.08								
τ Leonis.	3 30				+0.09								
ξ Hydræ	−31 13				−0.17								
υ Leonis.	− 0 11				+0.10								
χ Urs. Maj.	48 25				−0.06								
β Virgin.	2 25				+0.07								

***Star residuals*—Continued.**

LAHAINA, EVENING LIST, JUNE, 1883.

Star.	δ	10	11	13	14	16	18	19
	° ′	s.	s.	s.	s.	s.	s.	s.
ζ Virginis.	00 00					−0.05		
17 H. Camel.	37 47	+0.12						
τ Bootis.	18 2	−0.07	+0.09			+0.02	0.00	
η Bootis.	18 59	−0.04	+0.03	−0.05		+0.01		
11 Bootis.	27 57			+0.07		+0.04		−0.11
α Draconis.	64 56	−0.03	+0.01	−0.01		−0.01	+0.02	
d Bootis.	25 39			+0.05			+0.07	
4 Urs. Min.	78 6					0.00		+0.01
α Bootis.	19 47		−0.12				−0.08	
f Bootis.	19 45			−0.04		−0.09		
ϑ Bootis.	+52 23	+0.01						
ρ Bootis.	30 53	−0.10				+0.04		
π Bootis.	16 55	−0.08						+0.05
109 Virginis.	2 23	+0.07	+.015	0.00	+0.04	−0.01		+0.03
α Libræ.	−15 33	+0.08		−0.01	−0.06	+0.07		−0.02
β Urs. Min.	74 38	−0.01	+0.02	+0.01	0.00		0.00	+0.12
β Bootis.	40 51		+0.02	−0.02	−0.04		+0.03	
ψ Bootis.	27 24		−0.14	+0.05	+0.07		+0.06	+0.01
β Libræ.	− 8 57						+0.06	−0.07
δ Bootis.	33 45		−0.02		+0.04			
γ Urs. Min.	72 15				0.00			
μ Bootis.	37 47							−0.02
β Cor. Bor.	29 31							−0.02
α Cor. Bor.	27 7				−0.03		−0.01	
α Serpentis.	6 48				−0.05		−0.12	
β Serpentis.	15 47				+0.02			

LAHAINA, MORNING LIST, JUNE, 1883.

Star.	δ	11	12	14	15	17	19	20
	° ′	s.	s.	s.	s.	s.	s.	s.
Br. 2777.	77 39	−0.01						
1 Pegasi.	19 18	0.00	+0.15					
β Cephei.	70 3		+0.02					
74 Cygni.	39 53	+0.03	−0.10					
ε Pegasi.	9 21	−0.02						
16 Pegasi.	25 23		−0.08					
α Aquarii.	− 0 53			−0.04			+0.08	+0.04
π Pegasi.	32 36		−0.16	+0.01				−0.01
24 Cephei.	71 46	0.00	+0.02	0.00	+0.01	0.00	+0.03	+0.01
γ Aquarii.	− 1 58	+0.06	+0.08	+0.03	+0.03	+0.03		−0.08
π Aquarii.	0 47	0.00	+0.04	+0.02	−0.03	−0.03	+0.03	+0.05
η Aquarii.	− 0 43	−0.05	+0.03	+0.05	0.00			

Star residuals—Continued.

LAHAINA, MORNING LIST, JUNE, 1883—Continued.

Star.	δ	11	12	14	15	17	19	20
	° ′	s.	s.	s.	s.	s.	s.	s.
ζ Pegasi.	10 13	−0.07		−0.02	−0.02	+0.02		+0.02
η Pegasi.	29 37	+0.04		−0.06	+0.04	−0.04	−0.10	−0.01
λ Pegasi.	22 57			+0.02	−0.03	−0.13	−0.04	−0.02
ι Cephei.	65 35			+0.01	0.00	+0.01	0.00	
λ Aquarii.	− 8 12				+0.02	−0.01	0.00	
ο Andromedæ.	41 42					+0.10	0.00	
α Pegasi.	14 35					+0.02	+0.02	−0.01
π Cephei.	74 45							0.00

HONOLULU, JUNE, 1883.

Star.	δ	26	27	28	29
	° ′	s.	s.	s.	s.
α Draconis.	64 56				0.00
d Bootis.	25 39				−0.06
a Bootis.	19 47				+0.05
f Bootis.	19 45				−0.02
ρ Bootis.	30 53				+0.04
π Bootis (pr.).	16 55	+0.13			
109 Virginis.	2 23	−0.04	−0.04		
α Libræ.	−15 33	−0.02	−0.01		
β Urs. Min.	74 38	+0.02	−0.01	+0.01	−0.02
β Bootis.	40 51	−0.10	+0.05	−0.11	
ψ Bootis.	27 24		+0.03	+0.03	+0.04
β Libræ.	− 8 57				−0.09
δ Bootis.	33 45			+0.08	
γ Urs. Min.	72 15	+0.01		+0.01	
β Cor. Bor.	29 31			+0.02	
α Cor. Bor.	27 7	−0.01	−0.05	−0.09	
α Serpentis.	6 48	−0.02	+0.09	+0.03	+0.03
β Serpentis.	15 47		−0.01	−0.09	+0.02
χ Serpentis.	18 30		+0.03	+0.14	+0.04
ζ Urs. Min.	78 9		+0.01		
ε Cor. Bor.	27 13	−0.07	−0.04		
δ Ophiuchi.	− 3 24	+0.14			
ε Ophiuchi.	− 4 24	+0.05			
τ Herculis.	46 36	+0.03			

Star residuals—Continued.

SAN FRANCISCO, JULY, 1883.

Star.	δ	15	19	20	27	28
	° ′	s.	s.	s.	s.	s.
ν^1 Bootis.	41 14	−0.15		+0.10		
α Cor. Bor.	27 7			−0.06		−0.05
α Serpentis.	6 48	+0.04		+0.01		0.00
β Serpentis.	15 47	+0.09		+0.07		
χ Serpentis.	18 30	+0.03		−0.08		
ε Serpentis.	4 50					+0.03
ζ Urs. Min.	78 9	+0.02		−0.01		
δ Ophiuchi.	− 3 24	−0.06		0.00		
ε Ophiuchi.	− 4 24	−0.03	+0.01	−0.05		
τ Herculis.	46 36		+0.12	+0.01		+0.04
η Draconis.	61 47		−0.02			−0.01
β Herculis.	21 45				+0.03	
A Draconis.	69 1	+0.05		−0.02	+0.05	
ζ Ophiuchi.	−10 20	−0.01				
η Herculis.	39 9		−0.10	+0.05	−0.15	+0.02
χ Ophiuchi.	9 34	+0.07			+0.15	0.00
ε Herculis.	31 6	−0.04			−0.09	−0.02
ζ Draconis.	65 52					0.00
β Draconis.	52 24				−0.08	
α Ophiuchi.	12 39				+0.10	
ι Herculis.	46 4				+0.02	
χ Draconis.	72 13				+0.03	
θ Herculis.	37 16		+0.10			
67 Ophiuchi.	2 56				−0.06	
o Herculis.	28 45				0.00	
72 Herculis.	9 33		−0.03			
η Serpentis.	− 2 56		−0.07			
109 Herculis.	21 43		−0.01			
χ Draconis.	72 41		+0.02			
α Lyræ.	38 41		+0.04			

Pendulum observations.

PAKAOAO, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		July.	h.		s.				s.
1	Out.	5	15.1	P.	0.9627559	+418	+ 68	− 5	0.9628040
2		5	18.9	D.	332	418	+131	−11	7870
3		6	23.0	D.	255	418	+135	−12	7796
4		6	2.9	D.	368	418	− 64	+ 4	7726
5		6	7.3	P.	788	418	−263	+20	7963
6		6	11.2	P.	981	418	−280	+19	8138
									7922
7	In.	6	15.6	P.	0.9627520	+440	−200	+11	0.9627771
8		7	19.0	W.	603	440	− 78	+ 1	7966
9		7	23.2	W.	354	440	− 31	− 4	7759
10		7	3.3	W.	397	440	−224	+16	7629
11		7	7.5	P.	638	440	−413	+37	7702
									7765
A	Out.	11	11.3	P.	827	+545	− 58	+ 3	8317
B		11	15.8	P.	546	545	+ 17	− 9	8099
C		12	19.4	D.	722	545	+ 78	−10	8335
D		12	23.4	D.	439	545	+147	−15	8116
									8217

UP.

E	Out.	12	5.8	W.	0.9623778	+545	+141	−45	0.9624419
F		12	4.6	W.	754	545	+ 71	−26	4344
G		12	6.2	W.	088	545	00	− 8	[Rejected.]
H		12	7.3	P.	359	545	− 27	+ 4	3881
I		12	8.8	P.	351	545	− 48	+ 1	3849
J		12	10.4	P.	807	545	− 58	+19	4313
K		12	11.9	P.	821	545	− 46	+17	4337
L		12	13.1	P.	4229	545	+ 10	+ 3	4787
									4276

Pendulum observations—Continued.

PAKAOAO, PENDULUM NO. 4.

DOWN.

No.	Pos.	Date. 1887.	Epoch of.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		July.	h.		s.				s.
1	Out.	8	13.6	P.	1.0071485	+512	−258	+32	1.0071771
2		8	18.4	W.	370	512	+ 37	+ 5	1924
3		9	22.9	W.	122	512	+ 60	+ 2	1696
4		9	3.6	W.	397	512	+ 56	+ 1	1966
5		9	7.4	P.	652	512	− 63	+12	2113
									1894
6	In.	9	12.0	P.	786	+512	−100	+16	2214
7		9	15.4	P.	631	336	− 43	+11	1935
8		10	20.2	D.	567	336	+ 47	+ 5	1955
9		10	0.1	D.	363	336	+ 54	+ 4	1757
10		10	3.9	D.	731	336	− 7	+ 3	2063
11		10	7.4	P.	806	336	− 84	+ 8	2066
									1998

UP.

No.	Pos.	Date. 1887.	Epoch of.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	10	12.7	P.	1.0068930	+336	− 32	+13	1.0069247
2		10	14.4	P.	503	552	− 56	+13	9012
3		10	16.0	P.	695	552	− 63	+ 9	9193
4		10	17.6	P.	655	552	− 53	− 2	9152
5		11	20.7	W.	395	552	+ 50	−13	8984
6		11	22.3	W.	387	552	+ 87	−27	8999
7		11	23.9	W.	483	552	+113	−34	9114
8		11	1.5	W.	581	552	+116	−40	9209
									9114
9	In.	11	5.1	D.	1.0069790	+552	+ 56	−25	1.0070373
10		11	4.7	D.	180	552	− 6	− 6	69720
11		11	6.3	D.	464	552	− 60	+ 9	69965
12		11	7.9	P.	534	552	− 86	+18	70018
13		11	9.4	P.	406	552	−103	+25	69880
									69991

***Pendulum observations*—Continued.**

HAIKU, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections.			Corrected period.
						Rate.	Temp.	Press.	
		June.	h.		s.				s.
1	Out.	26	13.5	P.	0.9627250	− 3	− 3	− 1	0.9627243
2		26	18.0	W.	107	− 3	+ 66	− 7	163
3		27	22.1	W.	078	− 3	+ 87	−10	152
4		27	2.3	W.	074	− 3	− 9	+ 1	063
5		27	6.5	P.	314	− 3	− 95	+12	228
6		27	10.5	P.	309	− 3	− 45	+ 4	265
									186
7	In.	27	14.2	P.	0.9627229	98	+ 32	− 6	0.9627157
8		27	17.6	D.	323	− 98	+ 77	−10	292
9		28	21.8	D.	181	− 98	+102	−13	172
10		28	1.9	D.	221	− 98	+ 44	+ 7	174
11		28	6.0	P.	238	− 98	− 53	+ 7	094
12		28	10.1	P.	398	− 98	− 55	+ 8	253
									190

UP.

No.	Pos.	Date.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	28	14.1	P.	0.9625481	− 34	− 4	− 1	0.9625442
2		28	15.5	P.	394	− 34	+ 51	−24	387
3		28	17.3	W.	235	− 34	+ 44	−24	221
4		28	18.8	W.	305	− 34	+ 59	−27	303
5		29	20.3	W.	325	− 34	+ 88	−34	345
6		29	21.7	W.	353	− 34	+111	−40	390
7		29	23.2	W.	189	− 34	+120	−47	228
8		29	0.5	W.	241	− 34	+113	−49	271
9		29	2.0	W.	177	− 34	+ 72	−37	178
10		29	3.4	W.	181	− 34	+ 15	−18	144
11		29	4.8	W.	171	− 34	− 31	− 2	104
12		29	6.3	P.	225	− 34	− 68	+14	137
									263
13	In.	29	7.8	P.	0.9625385	− 34	− 85	+25	0.9625291
14		29	9.5	P.	301	− 34	− 81	+25	211
15		29	11.3	P.	306	− 34	− 58	+ 9	223
16		29	12.7	P.	416	− 34	− 19	+12	375
									275

Pendulum observations—Continued.

HAIKU, PENDULUM No. 4.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections.			Corrected period.
						Rate.	Temp.	Press.	
		June.	h.		s.				s.
1	Out.	23	13.3	P.	1.0071234	− 37	− 30	+ 7	1.0071174
2		23	17.5	D.	119	− 37	+ 87	− 8	1161
3		24	22.0	D.	064	− 37	+126	−10	1143
4		24	2.3	D.	077	− 37	00	+ 6	1046
5		24	6.4	P.	176	− 37	− 97	+16	1058
6		24	10.8	P.	086	− 37	− 88	+18	0979
									1094
7	In.	24	13.7	P.	1.0070863	+118	+ 4	+ 4	1.0070989
8		24	17.6	W.	871	+118	+ 86	− 4	1071
9		25	22.0	W.	863	+118	+104	− 6	1079
10		25	2.3	W.	863	+118	+ 29	− 0	1010
11		25	6.7	P.	1036	+118	−119	+19	1054
12		25	10.5	P.	1097	+118	− 95	+15	1135
									1056

UP.

No.	Pos.	Date.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	In.	25	14.3	P.	1.0070726	+ 88	− 32	+10	1.0070792
2		25	15.8	P.	684	+ 88	+ 8	− 9	771
3		25	17.3	D.	594	+ 88	+ 37	−15	705
4		26	18.9	D.	557	+ 88	+ 48	−15	678
5		26	22.0	D.	551	+ 88	+ 92	−38	693
6		26	23.6	D.	413	+ 88	+ 60	−34	527
7		26	1.1	D.	554	+ 88	+ 35	−25	652
8		26	2.7	D.	646	+ 88	− 9	− 9	716
									692
9	Out.	26	4.6	D.	1.0070706	+ 88	− 56	+10	1.0070748
10		26	5.9	P.	575	+ 88	−106	+32	589
11		26	7.4	P.	790	+ 88	−140	+49	787
12		26	8.9	P.	788	+ 88	−160	+60	776
13		26	10.4	P.	740	+ 88	−151	+57	734
14		26	11.8	P.	872	+ 88	−127	+41	874
									751

Pendulum observations—Continued.

HONOLULU, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections.			Corrected Period.
						Rate.	Temp.	Press.	
		June.	h.		s.				s.
1	Out.	9	12.5	P.	0.9627177	− 9	− 3	+ 5	0.9627170
2		9	17.0	D.	169	− 9	+ 12	+ 2	74
3		10	21.2	D.	179	− 9	+ 17	+ 1	88
4		10	1.3	D.	147	− 9	− 11	+ 6	33
5		10	5.4	P.	206	− 9	− 11	+ 7	93
6		10	9.6	P.	202	− 9	− 17	+ 5	81
									73
7	In.	10	13.2	P.	0.9627152	−32	+ 16	+ 3	0.9627139
8		10	16.8	W.	185	−32	+ 27	− 5	175
9		11	20.8	W.	154	−32	+ 26	− 7	141
10		11	1.0	W.	260	−32	− 11	− 4	213
11		11	5.1	P.	276	−32	− 28	0	216
12		11	9.5	P.	180	−32	− 6	− 3	139
									170

UP.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected Period.
1	Out.	11	13.8	P.	0.9625436	−13	+ 10	−22	0.9625411
2		11	15.2	P.	347	−13	+ 10	−22	322
3		11	16.7	D.	404	−13	+ 10	−23	378
4		12	18.2	D.	343	−13	+ 11	−23	318
5		12	19.7	D.	279	−13	+ 18	−25	259
6		12	21.3	D.	269	−13	+ 24	−27	253
7		12	22.8	D.	346	−13	+ 21	−27	327
8		12	0.8	D.	365	−13	+ 10	−23	339
9		12	2.2	D.	409	−13	− 11	−16	369
10		12	3.7	P.	593	−13	− 30	− 4	546
11		12	5.1	P.	263	−13	− 25	+ 2	227
12		12	6.8	P.	325	−13	− 29	+10	293
									337
13	In.	12	10.4	P.	0.9625123	−13	− 57	+19	0.9625072
14		12	12.2	P.	213	−13	−126	+42	5116
									5094

Pendulum observations—Continued.

HONOLULU, PENDULUM NO. 4.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		June.	h.		s.				s.
1	Out.	6	13.1	P.	1.0071132	+ 2	+88	−16	1.0071206
2		6	17.2	W.	025	+ 2	+79	−12	094
3		7	21.8	W.	133	+ 2	+76	−12	199
4		7	2.2	W.	120	+ 2	+40	− 6	156
5		7	5.6	P.	173	+ 2	0	+ 2	177
6		7	9.5	P.	183	+ 2	− 2	+ 1	184
									169
7	In.	7	13.8	P.	1.0071128	−17	+10	− 4	1.0071117
8		7	16.8	D.	057	−17	+13	− 4	049
9		8	21.2	D.	077	−17	+33	− 6	087
10		8	1.2	D.	017	−17	+ 7	− 3	004
11		8	5.0	P.	133	−17	−32	+ 5	089
12		8	9.2	P.	108	−17	−31	+ 6	066
									069

UP.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	8	13.7	P.	1.0070898	−15	− 2	+ 4	1.0070885
2		8	15.2	P.	899	−15	− 3	+ 8	889
3		8	16.3	W.	722	−15	− 8	+21	720
4		8	17.8	W.	749	−15	− 1	+26	759
5		9	19.6	W.	674	−15	−12	+24	671
6		9	21.1	W.	566	−15	+45	+ 1	597
7		9	22.6	W.	745	−15	+26	+ 8	764
8		9	0.2	W.	638	−15	−12	+20	631
									740
9	In.	9	1.8	W.	1.0070896	−15	− 9	+15	1.0070887
10		9	3.4	W.	740	−15	−18	+15	722
11		9	4.8	P.	799	−15	−24	+20	780
12		9	6.7	P.	742	−15	−29	+32	730
13		9	8.4	P.	827	−15	−39	+36	809
14		9	9.9	P.	930	−15	−41	+36	910
15		9	10.6	P.	866	−15	−26	+29	854
									813

Pendulum observations—Continued.

SAN FRANCISCO, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		Sept.	h.		s.				s.
1	Out.	15	20.3	P.	0.9622045	−141	−148	+22	0.9621778
2		15	23.6	H.	1764	−141	+ 36	0	659
3		16	3.8	H.	544	−141	+192	−20	575
4		16	8.2	P.	539	−141	+154	−17	535
5		16	12.0	P.	725	−141	− 61	+12	535
6		16	16.0	H.	699	−141	+ 14	+ 4	576
7		16	19.9	H.	547	−141	+202	−20	588
									607
8	In.	17	0.0	P.	0.9621599	−141	+266	−27	0.9621697
9		17	4.1	P.	557	−141	+266	−29	653
10		17	8.0	H.	535	−141	+162	−18	538
11		17	12.1	H.	721	−141	+ 27	+ 1	608
12		17	16.0	P.	707	−141	+114	− 8	672
									634

UP.

No.	Pos.	Date.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	19	19.1	P.	0.9620009	−126	−207	+98	0.9619774
2		19	20.5	P.	19933	−126	− 97	+61	771
3		19	22.0	P.	857	−126	− 10	+26	747
4		20	23.5	H.	758	−126	+ 41	+ 3	676
5		20	1.0	H.	633	−126	+ 92	−15	584
6		20	2.5	H.	651	−126	+143	−33	635
7		20	3.9	H.	537	−126	+186	−47	550
8		20	5.4	H.	523	−126	+218	−64	551
9		20	6.9	H.	546	−126	+190	−65	545
									648
10	In.	20	9.7	P.	0.9619468	−126	+107	−40	0.9619409
11		20	11.5	P.	555	−126	− 7	− 1	421
12		20	13.1	P.	698	−126	−134	+45	483
13		20	14.5	P.	758	−126	−234	+82	480
14		20	15.9	P.	878	−126	−263	+94	583
									475

Pendulum observations—Continued.

SAN FRANCISCO, PENDULUM NO. 4.

DOWN.

No.	Pos.	Date, 1887.	Epoch.	Obs.	Period.	Corrections.			Corrected period.
						Rate.	Temp.	Press.	
		Sept.	h.		s.				s.
1	Out.	13	19.0	P.	1.0065262	—172	— 26	+ 6	1.0065070
2		14	0.0	H.	5361	—172	+ 90	— 21	5258
3		14	4.0	H.	5299	—172	+205	— 36	5296
4		14	8.2	P.	5410	—172	— 88	+ 4	5154
5		14	12.8	P.	5982	—172	—669	+ 76	5217
6		14	15.9	H.	6092	—172	—631	+ 73	5362
									5226
7	In.	14	20.2	H.	1.0065803	—209	—333	+ 40	1.0065301
8		14	23.7	P.	5616	—209	—117	+ 17	307
9		15	4.0	P.	5531	—209	— 43	+ 6	285
10		15	8.3	H.	5550	—209	—190	+ 18	169
11		15	11.9	H.	6012	—209	—545	+ 65	323
12		15	16.0	P.	6108	—209	—614	+ 76	361
									291

UP.

1	Out.	20	17.5	P.	1.0065070	—117	—155	+ 56	1.0064854
2		20	19.0	P.	4947	—117	— 10	— 4	817
3		20	20.5	P.	4886	—117	+ 76	— 39	806
4		20	22.0	P.	4476	—117	+138	— 67	430
5		20	23.5	H.	4632	—117	+205	— 98	622
6		21	1.0	H.	4543	—117	+269	—121	574
7		21	2.7	H.	4542	—117	+362	—160	627
8		21	4.1	H.	4370	—117	+370	—163	460
9		21	6.5	H.	4333	—117	+417	—181	452
									627
10	In.	21	8.3	P.	1.0064486	—117	+330	—144	1.0064555
11		21	9.7	P.	4389	—117	+169	— 82	359
12		21	11.6	P.	4389	—117	— 63	+ 5	214
13		21	13.4	P.	4790	—117	—209	+ 62	526
14		21	14.9	P.	4922	—117	—268	+ 86	623
15		21	16.3	P.	4840	—117	—290	+ 83	516
									466

***Pendulum observations*—Continued.**

LICK OBSERVATORY, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date, 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		Oct.	h.		s.				s.
1	Out.	13	8.8	P.	0.9622353	−142	+121	−10	0.9622322
2		13	12.9	P.	358	−142	+ 90	− 5	301
3		13	17.0	P.	373	−142	+ 89	− 5	315
4		13	21.5	K.	373	−142	+104	− 6	329
5		14	8.7	P.	308	−139	+120	−10	279
6		14	13.0	P.	308	−139	+102	− 5	266
7		14	17.1	P.	283	−139	+122	− 4	262
8		14	21.8	K.	288	−139	+132	− 4	277
									294
9	In.	15	9.0	P.	0.9622233	−147	+166	− 7	0.9622245
10		15	13.7	P.	266	−147	+140	− 3	256
11		15	17.9	P.	261	−147	+148	− 2	260
12		15	22.0	K.	236	−147	+166	− 5	250
13		16	8.8	P.	275	−154	+184	−15	290
14		16	13.0	P.	293	−154	+157	−13	283
15		16	17.2	P.	294	−154	+140	−10	270
16		16	22.1	K.	335	−154	+137	− 9	309
									270

UP.

No.	Pos.	Date, 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	17	9.0	P.	0.9619926	−147	+133	−31	0.9619881
2		17	10.6	P.	943	−147	+121	−33	884
3		17	11.8	P.	890	−162	+116	−33	811
4		17	13.3	P.	844	−162	+109	−27	764
5		17	14.7	P.	810	−162	+ 97	−20	725
6		17	16.2	P.	826	−162	+ 83	−17	730
7		17	17.6	P.	822	−162	+ 69	−13	716
8		17	19.6	P.	960	−162	+ 63	−14	847
9		17	21.9	K.	964	−162	+ 61	−18	845
10		17	23.4	K.	996	−162	+ 53	−16	871
11		17	0.9	K.	20000	−187	+ 52	−22	843
									811
12	In.	18	8.2	P.	0.9619926	−187	+ 61	−32	0.9619768
13		18	9.7	P.	19926	−187	+ 54	−38	755
14		18	11.1	P.	19872	−196	+ 46	−35	687
15		18	12.9	P.	19980	−196	+ 35	−34	785
16		18	14.4	P.	20020	−196	+ 33	−30	827
17		18	15.8	P.	19958	−196	+ 36	−26	772
18		18	17.3	P.	19948	−196	+ 23	−18	757
19		18	18.8	P.	20005	−196	+ 12	−12	809
20		18	20.0	P.	19978	−205	+ 4	− 9	768
21		18	22.2	K.	20010	−205	− 7	− 4	794
22		18	23.6	K.	20082	−205	16	− 0	861
									780

Pendulum observations—Continued.

LICK OBSERVATORY, PENDULUM No. 4.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		Oct.	h.		s.				s.
1	Out.	23	9.1	P.	1.0066265	−242	−15	+18	1.0066026
2		23	13.6	P.	275	−242	−41	+22	014
3		23	17.9	P.	292	−242	−63	+26	013
4		23	22.2	K.	305	−242	−51	+28	040
*5		24	8.7	P.	399	−242	−8	+7	[158]
6		24	13.2	P.	064	−14	−30	+8	028
7		24	17.5	P.	066	−14	−52	+9	009
8		24	22.3	K.	073	−14	−40	+4	023
									022
9	In.	25	8.8	P.	1.0066062	−14	−2	−8	1.0066038
10		25	13.1	P.	056	−14	−19	−7	16
11		25	17.4	P.	077	−14	−24	−5	34
12		25	22.2	K.	067	−14	−12	−6	35
13		26	8.8	P.	036	−07	−6	−10	13
14		26	13.2	P.	064	−07	−28	−10	19
15		26	17.7	P.	074	−07	−46	−7	14
16		26	22.0	P.	112	−07	−42	−8	55
									28

* Swing V is rejected; clock failed.

UP.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	20	8.3	P.	1.0065320	−242	−160	+32	1.0064950
2		20	9.8	P.	16	−242	−155	+27	46
3		20	11.3	P.	28	−230	−148	+21	71
4		20	12.8	P.	20	−230	−150	+18	58
5		20	14.3	P.	00	−230	−156	+21	35
6		20	15.9	P.	20	−230	−162	+24	52
7		20	17.3	P.	14	−230	−166	+25	43
8		20	18.8	P.	45	−230	−166	+25	74
9		20	22.5	K.	00	−230	−167	+23	26
10		20	0.1	K.	50	−230	−166	+20	74
									53
11	In.	21	8.2	P.	1.0065096	−223	−135	+8	1.0064746
12		21	9.7	P.	064	−223	−141	+15	715
13		21	11.2	P.	082	−223	−146	+15	728
14		21	13.0	P.	132	−223	−152	+23	780
15		21	14.5	P.	068	−223	−159	+34	720
16		21	15.0	P.	026	−223	−170	+32	665
17		21	17.5	P.	066	−223	−183	+55	715
18		21	19.0	P.	055	−223	−194	+65	703
19		21	22.2	K.	140	−223	−203	+73	787
20		21	23.7	K.	142	−223	−214	+78	783
									734

Pendulum observations—Continued.

WASHINGTON, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected. period.
		Dec.	h.		s.				s.
1	Out.	10	15.5	P.	0.9620474	+367	—19	+ 5	0.9620827
2		10	19.9	B.	453	+367	—38	+13	795
3		10	0.2	P.	517	+367	—47	+15	852
4		10	4.4	B.	508	+371	—47	+14	846
5		11	8.6	B.	482	+371	—47	+15	821
6		11	12.7	P.	512	+371	—58	+18	843
7		11	16.8	P.	491	+378	—58	+25	836
									832
8	In.	11	21.0	B.	0.9620560	+378	—63	+32	0.9620907
9		11	1.2	B.	530	+378	—51	+26	983
10		12	15.3	B.	676	+294	—71	+ 9	908
11		12	19.5	B.	677	+294	—81	+ 3	893
12		12	23.6	P.	645	+294	—60	— 8	871
13		12	3.7	P.	643	+294	—27	—14	896
									893

UP.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected. period.
1	Out.	13	8.0	B.	0.9618889	+334	—19	—44	0.9619160
2		13	9.5	B.	805	+334	—18	—43	078
3		13	11.0	B.	809	+334	—17	—61	065
4		13	12.5	B.	883	+334	—15	—73	129
5		13	14.0	B.	859	+334	—10	—84	099
									106
6	In.	13	15.5	P.	0.9618911	+281	—11	—81	0.9619100
7		13	16.8	P.	894	+281	—15	—71	089
8		13	18.2	P.	855	+281	—15	—65	056
9		13	19.6	P.	875	+281	—26	—60	070
10		13	21.0	P.	831	+281	—30	—58	024
11		13	22.7	P.	895	+281	—21	—70	085
12		13	0.7	P.	889	+281	—14	—81	075
									071

Pendulum observations—Continued.

WASHINGTON, PENDULUM NO. 4.

DOWN.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		Dec.	h.		s.				s.
1	Out.	14	12.5	B.	1.0064116	+315	+ 68	− 37	1.0064462
2		14	16.8	B.	27	+308	+ 29	− 29	435
3		14	20.2	P.	64	+308	− 12	− 22	438
4		14	1.4	P.	87	+308	+ 25	− 20	400
5		15	5.8	B.	72	+308	+ 18	− 12	386
6		15	10.1	B.	35	+319	+ 22	− 2	374
									416
7	In.	15	14.5	P.	1.0064195	+319	+ 4	+ 13	1.0064531
8		15	18.8	P.	56	+319	− 25	+ 23	473
9		15	22.1	B.	53	+319	− 25	+ 20	467
10		15	3.4	B.	39	+335	+ 12	+ 9	495
11		16	7.7	P.	15	+355	+ 43	− 2	511
12		16	11.0	P.	28	+335	+ 51	− 9	505
									497

UP.

No.	Pos.	Date. 1887.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	Out.	16	16.3	B.	1.0063866	+303	+ 36	− 31	1.0064174
2		16	17.8	B.	861	+303	+ 29	− 25	168
3		16	19.4	B.	802	+303	+ 29	− 22	112
4		16	20.9	B.	956	+303	+ 28	− 21	266
5		16	22.4	B.	866	+303	+ 55	− 18	206
6		16	1.1	P.	851	+303	+ 60	− 21	193
7		16	2.6	P.	913	+303	+ 78	− 23	271
8		17	12.2	P.	638	+345	+111	+ 34	128
9		17	13.7	P.	582	+436	+100	+ 36	154
10		17	15.1	P.	544	+436	+ 86	+ 38	104
									178
11	In.	17	7.9	B.	1.0063634	+436	+ 50	+132	1.0064252
12		17	9.4	B.	674	+436	+ 45	+169	324
13		17	10.9	B.	706	+436	+ 44	+176	362
14		17	12.4	B.	760	+436	+ 38	+185	419
15		17	13.9	B.	786	+436	+ 37	+179	438
									359

Pendulum observations—Continued.

CAROLINE ISLAND, PENDULUM No. 3.

DOWN.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		Apr.	h.		s.				s.
1	Out.	25	10.0	B.	0.9630201	+423	−57	− 6	0.9630561
2		26	14.6	B.	30084	+423	+ 4	− 4	09
3		27	10.5	B.	30173	+368	−36	+ 4	09
4		28	15.1	B.	30102	+368	+44	− 8	06
		May.							
5		6	13.0	B.	30169	+407	+11	+ 1	88
6		7	17.8	P.	30175	+407	−26	− 8	48
									36
		Apr.							
7	In.	28	11.8	B.	0.9630017	+402	+ 5	− 1	0.9630423
8		29	16.8	P.	30023	+402	+33	− 4	454
9		29	10.1	B.	30051	+392	−60	+11	394
10		30	14.6	B.	29931	+392	+15	+ 5	343
		May.							
11		7	10.7	B.	30003	+380	− 7	− 2	374
12		8	16.9	P.	29928	+380	−74	− 6	228
									369

UP.

No.	Pos.	Date.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
		Apr.							
1	Out.	30	11.1	B.	0.9627609	+360	+96	+ 0	0.9628065
2		30	12.9	B.	562	+360	+54	+19	7995
		May							
3		1	14.6	B.	619	+360	+19	+20	8018
4		1	16.6	P.	691	+360	− 3	+13	8061
5		1	18.6	P.	666	+360	−14	+ 3	8015
6		1	10.0	B.	677	+325	+86	+25	8113
									8044
7	In.	1	12.0	B.	0.9627657	+325	+14	+ 2	0.9627998
8		1	13.6	B.	504	+325	−15	− 9	7805
9		2	15.2	B.	579	+325	−39	−12	7853
10		2	16.6	B.	524	+325	−66	−17	7766
11		2	18.4	P.	679	+325	−81	−23	7900
									7864

Pendulum observations—Continued.

LAHAINA, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Corrections.			Corrected period.
						Rate.	Temp.	Press.	
		June.	h.		s.				s.
1	Out.	11	15.1	B.	0.9627328	+299	+ 61	− 6	0.9627682
2		12	20.1	P.	206	+299	+237	−27	715
									699
3	In.	13	15.4	B.	0.9627447	+308	− 67	+10	0.9627698
4		14	20.4	P.	307	+308	+146	−13	748
5		14	15.5	B.	456	+335	− 20	+ 3	774
6		15	20.3	P.	328	+335	+135	−14	784
									751
7	Out.	16	14.5	B.	0.9627543	+267	− 92	+10	0.9627728
8		17	19.5	P.	353	+267	+ 93	−11	702
									715

UP.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Rate.	Temp.	Press.	Corrected period.
1	In.	18	15.5	B.	0.9625064	+292	−153	+45	0.9625248
2		18	17.0	B.	5075	+292	− 88	+25	304
3		19	18.5	B.	4934	+292	− 56	+18	188
4		19	20.3	P.	4886	+292	+ 20	− 5	193
5		19	21.9	P.	4817	+292	+103	−31	181
									223
6	Out.	19	15.1	B.	0.9625226	+307	−156	+44	0.9625421
7		19	16.8	B.	5047	+307	−101	+28	281
8		20	18.5	B.	4947	+307	− 68	+18	204
9		20	20.2	P.	4987	+307	− 12	− 2	280
10		20	21.8	P.	4451	+307	+ 13	− 2	269
									291

Pendulum observations—Continued.

HONOLULU, PENDULUM NO. 3.

DOWN.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		June.	h.		s.				s.
1	Out.	26	15.2	B.	0.9627154	+438	+19	− 4	0.9627607
2		27	19.6	B.	132	+438	+31	+ 5	606
3		27	21.8	P.	075	+438	+46	− 8	551
4		27	2.0	P.	130	+438	+10	− 4	574
5		27	7.0	B.	205	+438	−54	+ 6	595
6		27	11.7	B.	240	+438	−32	+ 3	649
									597
7	In.	27	15.3	P.	0.9627190	+431	+10	− 3	0.9627628
8		28	19.4	P.	176	+431	+37	− 6	638
9		28	22.3	B.	118	+431	+56	− 9	596
10		28	2.6	B.*	110	+431	+25	− 6	560
11		28	7.0	P.	159	+431	−46	+ 5	549
12		28	11.3	P.	225	+431	−56	+ 6	606
									596

UP.

1	Out.	28	16.3	B.	0.9624815	+415	+10	− 8	0.9625232
2		28	17.7	B.	816	+415	+19	− 8	242
3		28	19.3	B.	794	+415	+29	−11	217
4		28	20.8	B.	762	+415	+40	−15	202
5		28	22.4	P.	778	+415	+44	−15	222
6		28	23.9	P.	745	+415	+46	−16	190
7		28	1.5	P.	765	+415	+20	− 9	191
8		29	2.7	P.	794	+415	+20	− 5	224
									215
9	In.	29	4.4	P.	0.9624782	+415	−14	+ 6	0.9625189
10		29	6.2	B.	727	+415	−36	+15	5121
11		29	7.8	B.	730	+415	−38	+27	5134
12		29	9.5	B.	614	+415	−82	+43	4990
13		29	10.8	B.	731	+415	−74	+36	5108
14		29	12.4	B.	828	+415	−72	+32	5203
15		29	15.8	B.	931	+415	−15	+ 7	5338
									5155

Pendulum observations—Continued.

SAN FRANCISCO, PENDULUM No. 3.

DOWN.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		July.	h.		s.				s.
1	Out.	15	15.9	P.	0.9621630	+257	+132	− 7	0.9622012
2		15	20.5	P.	498	+257	+226	−17	1964
3		15	1.0	P.	446	+257	+217	−15	1905
4		15	5.2	P.	566	+257	− 44	+16	795
5		16	9.8	H.	825	+257	−305	+49	826
6		16	14.1	H.	791	+257	−139	+28	937
7		16	18.4	P.	544	+257	+121	− 5	917
8		17	23.1	P.	462	+257	+195	−16	898
9		17	3.0	H.	347	+257	+210	−21	793
10		17	7.4	H.	453	+257	+110	−13	807
11		17	11.3	P.	532	+257	+137	−16	910
12		17	14.9	P.	465	+257	+200	−25	897
13		17	19.4	H.	380	+257	+231	−32	836
14		18	23.5	H.	352	+257	+247	−38	818
15		18	3.7	P.	385	+257	+198	−36	804
16		18	8.5	P.	568	+257	− 13	−12	800
17		18	12.1	H.	698	+257	− 81	− 2	872
18		18	16.3	H.	584	+257	+104	−25	920
19		18	19.4	P.	470	+257	+205	−37	895
20		19	23.2	P.	397	+257	+260	−45	869
21		19	3.7	H.	620	+257	+ 16	−16	877
22		19	8.1	H.	877	+257	−345	+35	824
23		19	13.3	P.	2005	+257	−338	+31	955
									1875
24	In.	19	17.2	P.	0.9621705	+200	+ 10	− 1	0.9621914
25		20	22.2	H.	459	+200	+175	−18	816
26		20	2.7	H.	430	+200	+ 90	− 8	712
27		20	7.7	P.	685	+200	−149	+26	762
28		20	12.1	P.	794	+200	−181	+28	841
29		20	16.1	H.	566	+200	+ 59	+ 7	832
30		21	20.3	H.	387	+200	+180	− 9	758
31		21	1.2	P.	337	+200	+209	−14	732
32		21	5.5	P.	531	+200	+ 4	+ 9	744
33		21	9.7	H.	856	+200	−177	+33	912
34		21	14.0	H.	629	+200	− 38	+14	805
									803

Pendulum observations—Continued.

SAN FRANCISCO, PENDULUM NO. 3—Continued.

UP.

No.	Pos.	Date. 1883.	Epoch.	Obs.	Period.	Corrections. Rate.	Temp.	Press.	Corrected period.
		July.	h.		s.				s.
1	Out.	27	17.2	P.	0.9619356	+369	— 4	+ 1	0.9619722
2		27	19.0	P.	582	+369	+ 14	— 10	955
3		28	20.7	H.	599	+369	+ 19	— 16	971
4		28	22.4	H.	446	+369	+ 37	— 25	827
5		28	0.7	H.	144	+369	+ 38	— 26	525
6		28	2.2	H.	078	+369	+ 16	— 21	442
7		28	4.1	H.	077	+369	— 14	— 18	414
8		28	5.8	P.	215	+369	—117	+ 17	484
9		28	7.5	P.	218	+369	—242	+ 55	400
10		28	9.3	P.	261	+369	—322	+ 85	393
11		28	11.0	P.	370	+369	—400	+113	452
12		28	12.5	P.	270	+369	—429	+123	333
13		28	14.4	P.	460	+369	—312	+ 82	599
									578

Reduction to standard temperature and pressure.

OBSERVATIONS OF 1887.

[Pressure, 29.55 inches. Temperature, 15° C.]

Station.	Pendulum No. 3.		Pendulum No. 4.	
	Down.	Up.	Down.	Up.
	s.	s.	s.	s.
Pakaoao.	0. 9628031	0. 9624276	1. 0071946	1. 0069553
Temperature correction.	+ 517	+ 517	+ 542	+ 542
1st atmospheric correction.	+ 848	+ 2405	+ 904	+ 2701
2d atmospheric correction.	+ 54	+ 162	+ 66	+ 196
	0. 9629450	0. 9627360	1. 0073458	1. 0072992
Haiku.	0. 9627188	0. 9625269	1. 0071075	1. 0070722
	— 776	— 775	— 815	— 814
	+ 91	+ 259	+ 97	+ 291
	+ 1	+ 4	+ 2	+ 5
	0. 9626504	0. 9624755	1. 0070359	1. 0070204
Honolulu.	0. 9627172	0. 9625215	1. 0071119	1. 0070776
	— 1091	— 1090	— 1146	— 1145
	+ 82	+ 232	+ 87	+ 261
	— 1	— 2	— 1	— 3
	0. 9626162	0. 9624355	1. 0070059	1. 0069889
San Francisco.	0. 9621620	0. 9619560	1. 0065258	1. 0064546
	— 221	— 221	— 232	— 232
	+ 33	+ 93	+ 35	+ 104
	+ 1	+ 2	+ 1	+ 3
	0. 9621433	0. 9619434	1. 0065062	1. 0064421
Lick Observatory.	0. 9622282	0. 9619795	1. 0066025	1. 0064845
	+ 31	+ 31	+ 32	+ 32
	+ 386	+ 1095	+ 411	+ 1229
	+ 22	+ 68	+ 27	+ 82
	0. 9622721	0. 9620989	1. 0066495	1. 0066188
Washington.	0. 9620863	0. 9619089	1. 0064455	1. 0064268
	— 155	— 155	— 163	— 163
	— 29	— 84	— 31	— 94
	— 2	— 7	— 3	— 9
	0. 9620677	0. 9618843	1. 0064258	1. 0064002

Reduction to standard temperature and pressure—Continued.

OBSERVATIONS OF 1883.

[Pressure, 29.55 inches. Temperature, 15° C.]

Station.	Pendulum No. 3. Down.	Up.
	s.	s.
Caroline Island.	0.9630452	0.9627954
Temperature corr.	− 998	− 999
1st atmos. corr.	+ 90	+ 255
2d atmos. corr.	0	+ 1
	0.9629544	0.9627211
Lahaina.	0.9627729	0.9625256
	− 699	− 670
	+ 34	+ 98
	− 1	− 4
	0.9627093	0.9624680
Honolulu.	0.9627595	0.9625185
	−1044	−1045
	+ 64	+ 182
	− 1	− 3
	0.9626614	0.9624319
San Francisco.	0.9621840	0.9619578
	− 105	− 105
	+ 10	+ 28
	0	0
	0.9621745	0.9619501

Reducing on the principle of the reversible pendulum we have

$$\text{Pendulum No. 3.}\quad T = T_u + 1.529\,(T_d - T_u)$$

$$\text{Pendulum No. 4.}\quad T = T_u + 1.506\,(T_d - T_u)$$

the numerical factor being the value of the fraction $\frac{hd}{hd - hu}$. Pendulum No. 4 with the heavy end up at San Francisco does not accord with the other stations, and the period for this position is deduced from heavy end down, using a mean value for the difference between down and up at other stations. Equal weight has been given to the observations with Pendulum No. 3, Down, at Pakaoao, before and after July 8.

We then have the following relative periods as the result of the observations:

Periods of oscillation at 29.554 inches of reduced barometer at Washington and at 15° Centigrade.

1887. Pendulums 3 and 4.		1883. Pendulum 3.	
Station.	T.	Station.	T.
Pakaoao.	1.000929	Caroline Island.	1.000815
Haiku.	605	Lahaina.	565
Honolulu.	574	Honolulu.	509
San Francisco.	085	San Francisco.	000
Lick Observatory.	220		
Washington.	000		

Grouping together those stations at which the same support and head were used, we have

Group I.—1887.		Group II.—1883.		Group III.	
Station.	T.	Station.	T.	Station.	T.
Pakaoao.	1.000709	Caroline Island.	1.000815	San Francisco.	1.000085
Haiku.	385	Lahaina.	565	Washington.	000
Honolulu.	354	Honolulu.	509		
Lick Observatory.	000	San Francisco.	000		

Taking a mean between the connection Washington—San Francisco as given by the Peirce and Kater pendulums we have 1.000073, and connecting the whole series by means of Honolulu in the first two groups, and San Francisco in the last two, the dissimilar conditions are eliminated.

This combination gives the following table of relative times of oscillation and values of gravity:

Station.	φ	λ	h	t	g	Observers.
	° ′	° ′	*Feet.*			
Washington.	+38 53	77 1	34	1.000000	1.000000	Preston, Baylor.
San Francisco.	+37 47	122 26	378	073	0.999854	Preston, Hill.
Lick Observatory.	+37 20	121 39	4,205	228	9544	Preston, Keeler.
Honolulu.	+21 18	157 52	10	582	8837	Preston, Dodge, Wall.
Haiku.	+20 56.	156 20	385	613	8775	Preston, Dodge, Wall.
Pakaoao.	+20 43	156 15	9,846	937	8129	Preston, Dodge, Wall.
Lahaina.	+20 52	156 41	10	638	8725	Preston, Brown.
Caroline Island.	—10 0	150 14	7	888	8226	Preston, Brown.


Kipahulu
Kaupo
Kohala Centre
Waipio Valley
Mahukona
Kawaihae
5505 ft.
Laupahoehoe
20°
Mauna Kea
13 805 ft.
HILO
Mt. Hualalai
8275 ft.
Kailua
H A W A I I
Kealakeakua Bay
Mauna Loa
13 675 ft.
Kilauea
4040 ft.
Keauhou
Milolii
Punaluu
Waiohinu
Honuapo
19°
Kaalualu
Ka Lae
156°
155°